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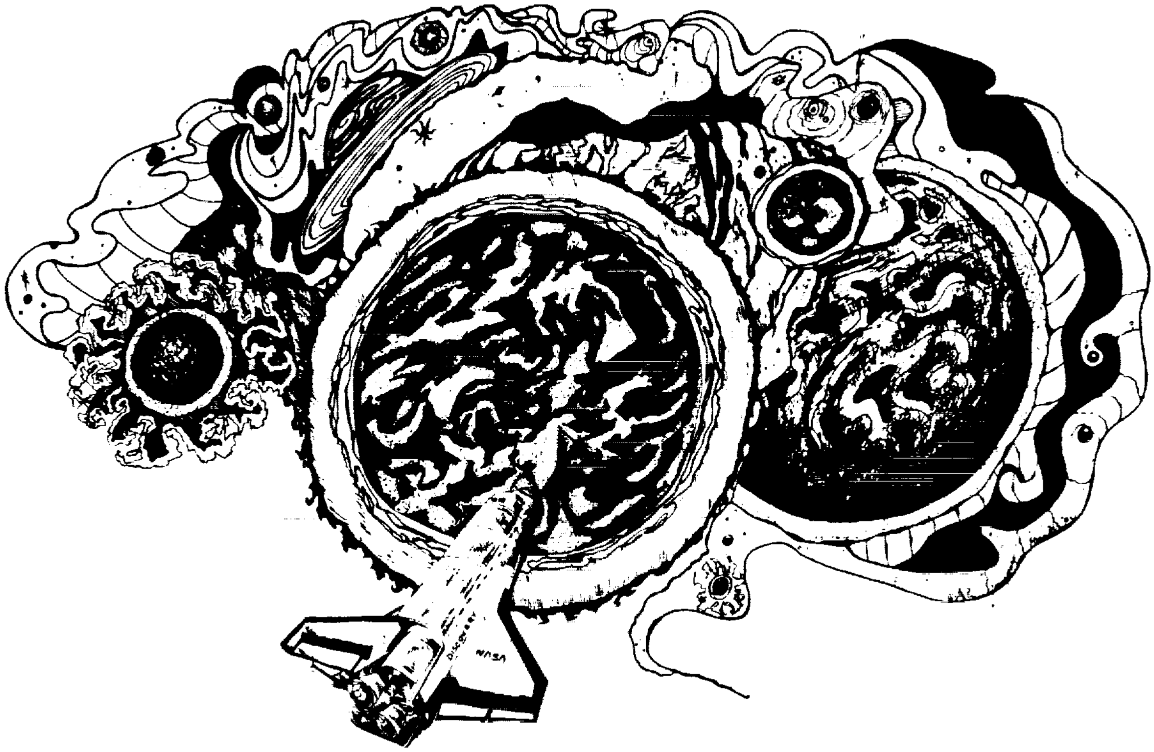

(NASA-CR-193182) MAGNETIC EARTH IONOSPHERE RESONANT FREQUENCIES (MEIRF) PROJECT Semiannual Progress Report, Sep. 1992 - Mar. 1993 (West Virginia State Coll.) 69 p

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WEST VIRGINIA STATE COLLEGE
COMMUNITY COLLEGE DIVISION
NASA-MEIRF PROJECT
PROGRESS REPORT JUNE 1993

MAGNETIC EARTH IONOSPHERE RESONANT FREQUENCIES
NAG-5-1267

Prepared for

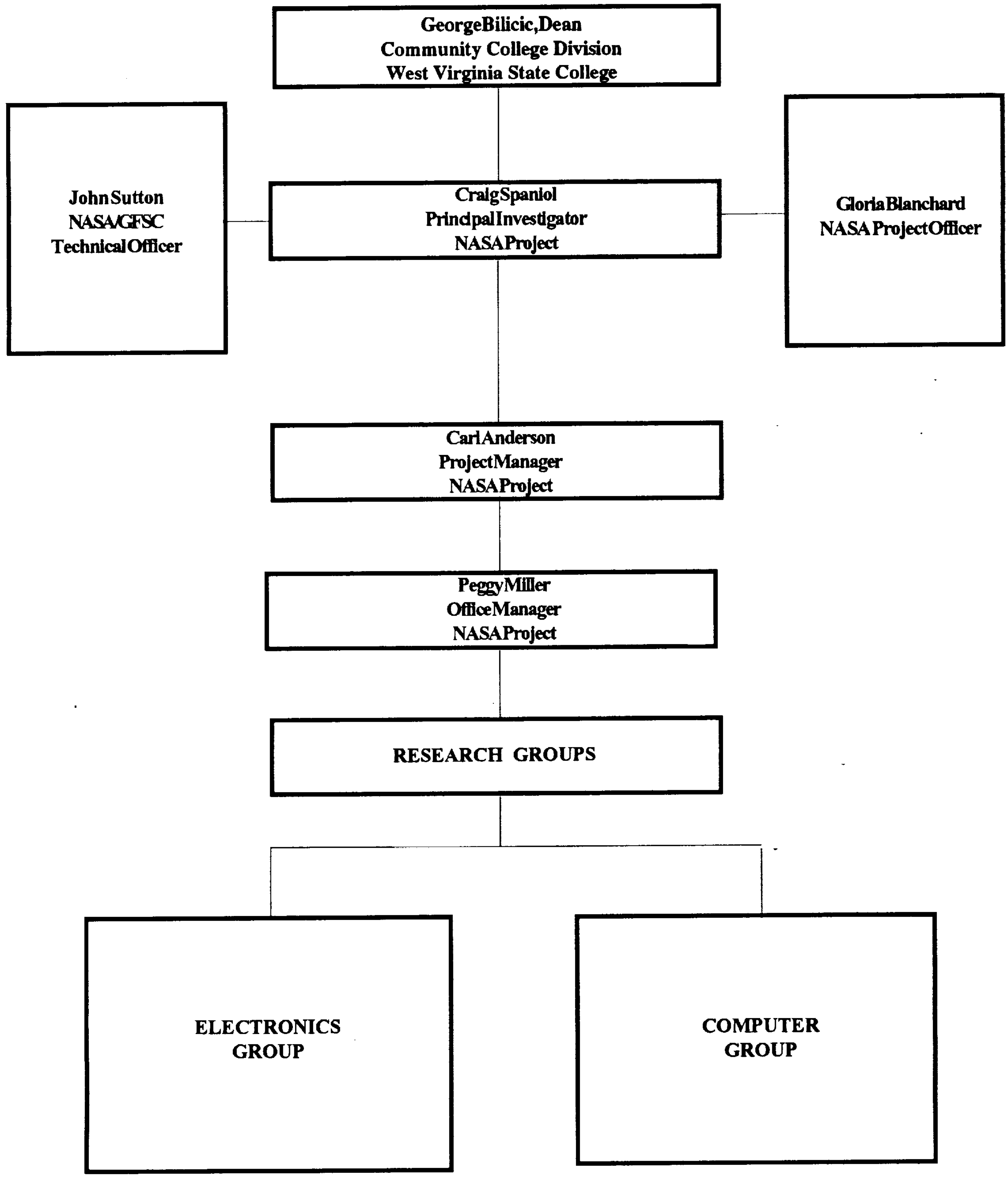
Dr. John Sutton
Technical Officer, NASA Project
Goddard Space Flight Center
Greenbelt, Maryland 20771

Prepared by

Research Assistant Groups
NASA MEIRF Project
Community College Division
West Virginia State College

June 15, 1993

Project Organizational Chart



PROJECT PERSONNEL

Administration

Dean, Community College Division . . . Dr. George Bilicic

Staff

Principal Investigator . . . . Dr. Craig Spaniol
Project Manager . . . . Carl Anderson
Office Manager . . . . Peggy Miller

Research Assistant Groups

Computer Group . . . . Joe Adams *
Barbara Adams
Tom Rowsey

Electronic Group . . . . Bill Bailey
Janine Patterson *
Bill Ross
Don Bishop

* Supports both groups

Table of Contents

MESSAGE FROM DR. GEORGE BILICIC, DEAN
COMMUNITY COLLEGE DIVISION, WEST VIRGINIA STATE COLLEGE

The Community College Division at West Virginia State College is pleased to report another successful period of NASA funded research. The investigation into Earth-Ionosphere cavity resonanant frequencies has continued to involve current and former students from a variety of disciplines in scientific and project activities. The NASA-MEIRF project demonstrates the potential for government and education cooperating to become an example of and injunction for more vigorous research activity at the College and in the region.

The project presented a different subject for the second annual "Day of Discovery" at the College. The theme was directed to economic development utilizing the name and example of George Washington Carver Partnerships. The program brought together representatives of government, education, and industry-labor with the purpose of economic expansion. The contacts developed and cooperative spirit from the program have already resulted in pilot funding for an economic development program in the state.

The College's educational mission has been further enhanced, in addition to the research and student involvement, by an additional paper, "G" jointly presented by John Sutton and Craig Spaniol at the "Sir Isaac Newton International Scientific Conference" held in St. Petersburg, Russia, in March 1993. Another joint paper by the same authors, titled "A Broadband Active Antenna for ELF Magnetic Fields," has been published in the Canadian physics journal "Physics Essays". This concept has been developed as an outgrowth of project research but has potential for additional research applications.

We at the Community College are pleased with the research being conducted with NASA-Goddard Space Flight Center and look forward to expansion of research in the future.

OVERVIEW

During this contract period, the two most significant and professionally rewarding events were the presentation of our research activity at the Sir Isaac Newton Conference in St. Petersburg, Russia, and the second Day of Discovery Conference, focusing on economic recovery in West Virginia.

The Day of Discovery II Conference focused on the concept of building partnerships between business, education, government, and labor to enhance economic development activity in the state. Formal presentations were given by professionals who have operating partnership programs in other states.

Following the seminars, a satellite uplink panel discussion was broadcast. The West Virginia State College economic development initiative is titled the "George Washington Carver Partnership." This program has been funded by a grant from the Joint Commission on Vocational-Technical Education in West Virginia.

Following our submission of the paper titled "G" to the local organizing committee for the Sir Isaac Newton Conference, (LOC), the Institute for Theoretical Physics in Kiev, Ukraine, reviewed and recommended acceptance to the LOC for presentation at the conference. We were formally notified by the LOC and began preparation for attendance. The presentation was well received and informal interactions with scientists from the former Soviet Union were very enlightening. We plan to continue these dialogues and hope to establish joint research activities.

An active antenna concept authored jointly by John Sutton and Craig Spaniol titled "A Broadband Active Antenna for ELF Magnetic Fields" was published in the Canadian physics journal "PHYSICS ESSAYS" during this period (Appendix D). This circuit concept has potential for further development in future periods. The device utilizes a signal feedback principle similar to regenerative receivers used in early radio. The device has potential for ELF research and other commercial applications for improved signal reception; but the basic circuits now need further refinement and development for feedback and control purpose before practical use is possible. Goddard SFC is presently processing two patents associated with the theoretical concepts contained in this paper.

Finally, work continues to progress on the development of a prototype monitoring station. Signal monitoring, data display, and data storage are major areas of activity. In addition, we plan to continue our dissemination of our research activity through presentations at seminars and other universities.

COMPUTER DIVISION
Student Progress Report

The computer division of Project MEIRF has accomplished several things during this progress period. We have developed a PC-based prototype for an automatic data transfer system that will transfer data being accumulated from remote sites to a central site presently located at West Virginia State College. This will enable data to be analyzed for further comparative studies. This new system is similar to the previously developed one with a major improvement in memory capabilities, enhancing the systems operating capacity. It can now function on an XT with minimal memory requirements. At least once a week data must be moved to add space for new incoming data.

We are initiating work with a NASA-Goddard furnished VAX 11-750 to process and store incoming data on dedicated platters and tapes. Presently, data is being stored on the hard drive of the same computer used to analyze the stored data. With new data always coming in, this space is diminishing rapidly. A future goal is for a more automated system that requires less human effort for handling and analyzing data. This will allow time to be given to other areas of study including analyzation of the data itself.

We have implemented a computer care system to safeguard our computer system. Recently, a virus scare heightened our awareness of a need for better computer maintenance. A new backup routine, which should provide us with adequate protection in the event that a computer virus actually takes place on any of the systems, is now operational. We have also installed a special type of anti-virus program that can scan the files each time the computer is booted up. It can also immunize certain files against a virus. In the immunization, it makes the file read-only so that nothing can be added on or attached.

The NASA Project has been furnished with several accounts in the College's VAX system. We have direct line connections to the College VAX which saves time, eliminates the need to tie-up a phone line to connect, and gives increased data transfer rates. These accounts will offer us many benefits, including a way in which to store and analyze data quickly. These data are then compared to data on the program's VAX 11-750 system to check to see if the results are the same.

One account has been used for communication with Russia through E-mail, which is more cost efficient than faxing or communicating by telephone. Work continues on the VAX hardware and software for project utilization. Also, Joe and Barbara Adams have been on the road recording data. They made a stop in a low-noise area in Texas where they acquired some very interesting traces. Joe has also been working on a new antenna setup which should provide us with even better data than before. The Project also acquired a new disk storage pack for the HP spectrum analyzer which will allow him to save more data, and he hopes to be able to keep the system fully active in order to monitor real-time data continually.

The NASA Project is also pleased to announce the addition of a new member to the electronics group, Janine Patterson, who will be providing us with her knowledge of both electronics and computer software.

ELECTRONIC GROUP PROGRESS REPORT

During this progress period, analyses were conducted on traces of extremely low frequencies in the earths ionosphere cavity detected by a Hewlett Packard 35660 Dynamic Signal Analyzer. The purpose of this experiment was to incorporate the traces into a computer program that will execute the following steps:

1. Read data from a single trace without altering these data.
2. Show data on a computer monitor as seen by the spectrum analyzer.
3. Toggle between any two traces or sequence of traces that show a variation in data.

The traces being analyzed were produced over a 24-hour period.

This approach would enable the viewer to see any changes within a particular set of traces in a timely manner. Once such changes have been recognized, the viewer can analyze these data by toggling between the traces where the change occurs. By viewing traces in this manner, the coordinates, where the change in the frequencies occur, can be examined in greater detail. To further examine changes that occurred, these traces can be printed and their physical aspect examined. Once a program had been selected that was capable of meeting the requirements necessary, we began to realize the limitations of our hardware. In order for this experiment to be successful, the speed that the computer requires in order to execute a program is important to meeting our goal.

EXPERIMENTAL PROGRESS REPORT

We are continuing with the same objectives as given in the last report. The electronics group is focussed on upgrading receiving signal detectors. The computer group is experimenting with methods to optimize spectrum analyzer results. Development and implementation of a simplified method to transfer data files from a remote site recorder is now in field testing as a combined effort of the computer group and the electronics group. Work also continues on a self-contained recording device for remote locations. Preliminary work on integrating the various project computers with the VAX system and gaining access to WVnet/BITnet is progressing. Several improvements have resulted and the current priority of effort continues in these important areas.

In the area of electronics, efforts have been focussed on the improvement of signals received. To improve the signal-to-noise ratio from electromagnetic pickups, additional pickups have been constricted and tested. This involves the winding of coils with different gauge wire and the use of different types of core material. Preamplifiers are also being modified and results of these tests are being analyzed. Some preliminary differences have not been fully determined at this time.

The task of developing a rapid data viewing software package is now on the computer group's agenda. This will allow a large number of spectrum traces to be rapidly viewed for analyzing signals and trends. This will reduce excessive man hours and equipment needed to print and visually scan large number of traces resulting from continuous monitoring. The group's work on the software to convert and compare results from different manufacture's signal analyzers is progressing cautiously.

Presently, there are two different manufactures of spectrum analyzers used on the project, Hewlett Packard and Rapid Systems. The results need to be in a form that can be compared for incongruities. The results of this development will be useful in other areas of experimentation.

The fourth project field trip, during January, was taken to a distant remote Texas area. This was to gather additional data and to field test a data transfer system. Software to control the automated remote site was used. Refinement and updating is continuing with the acquisition of additional hardware. Prototype development is a high priority. Computer software used in these tests to access remote monitoring sites, as well as the data transfer system, indicates that this is a possible prototype to develop for a real-time monitoring station.

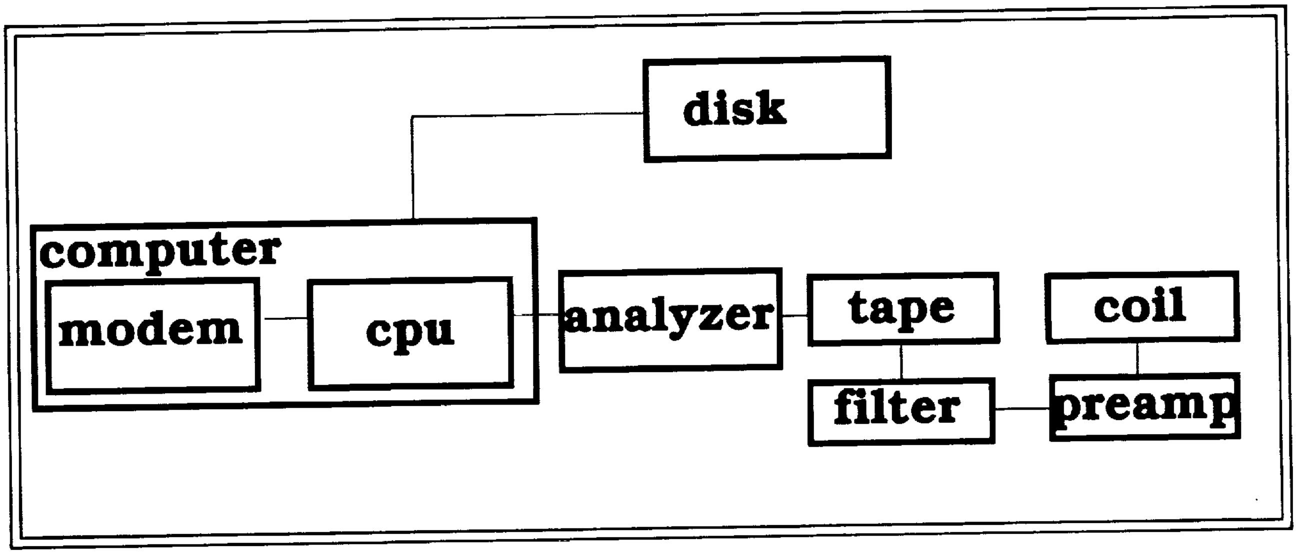
The first generation of a self-contained recording device, for remote locations, is nearing completion. This will allow us to gather more data for determining the viability of a remote location. Work on this unit will carry over to the development of a system for digitally recording the cavity spectrum from three to thirty hertz. This will allow the researchers to analyze the data in several ways and improve our acquisition process.

The Project now has several computers that are not interlinked. Plans are underway to link all Project computers to the VAX, which was recently transferred to the Project from GSFC. This will improve internal communications, record keeping, and storage of information. To improve external communication, plans are now under way to gain direct access to WVNET, the West Virginia Network, which will give us access to BITnet, NSFnet, and other national and international networks.

Experimentation also continues with receiving antennas. This factor is one of the most critical to monitoring success. Several different antenna types have been tested and compared. This effort has included location of the antennas, as well as shielding the effects from unwanted interference. This effort will continue in conjunction with improved amplification and filtering to determine optimum combinations.

Experimentation continues to find suitable sites for station location. Presently, intermittent operation of recording equipment is accomplished at two sites remote from West Virginia State College so that signal characteristics can be compared. Earlier experiments at the College location provided poor quality traces due to a high level of background noise, although experimentation at the College will continue.

A MOCK-UP OF REMOTE-ONE



Remote-One

COMPUTER

This is the system controller. The central processing unit (CPU) used in this mock-up is an XT Turbo Clone with a Hewlett Packard 82335A HP-IB Inter-face Card. Running the HP 82335A HP-IB Command Library requires software and command files written by the designer of this mock-up using Borland's Turbo Pascal version 6.0, GW-basic version 3.22 and Microsoft MS-DOS version 3.3. Also, an internal modem is accessed using Procomm-Plus Communica-tions package version 1.1A along with compression software by PKWARE Inc. Pkzip version 0.92.

ANALYZER

The Hewlette Packard 35660A Dual-channel Dynamic Signal Analyzer is the one used here. It is an FFT-based instrument that provides spectrum measurements in electronics. The HP 35660A performs spectrum analysis from .000488 Hz to 102.4 kHz. The FFT provides 401 lines of resolution.

DISK

A Hewlette Packard 9153C Data Storage Peripheral with a Winchester hard drive and 3.5" micro floppy is used to store traces recorded by the HP35660A.

TAPE

The raw data that is picked up by the coil, amplified, and clipped by the filter for the needed portion of the spectrum will be recorded on tape. This will be saved in order to verify the results later and to be able to view the same raw data in a variety of ways. Other recording devices are being examined. Considerations during these examinations are for longer recording periods of time and for a digital format.

FILTER

A Krohn-Hite model 3343 filter is used to block off the low and high portion of the signal that is not wanted for analysis.

PREAMP

A Pre-amplifier is utilized to increase the amplitude of the signal that enters the analyzer. This amplifies the signal as it is received from the coil. Then, as it encounters noise (interference) along the way to the analyzer, it is easier to distinguish the signal from the background noise. Work continues in this area.

COIL

The coil that is now being used is for test purposes only. A plastic spool with a two inch core is wound with five hundred feet of number sixteen copper wire. Several designs for pick-up coils are now being considered, but much work is needed in this area. Perhaps a computerized design program would be appropriate.

This set-up has been used on most of the field trips. A control program in the computer sets up the analyzer. At preset times traces are recorded. Daily, the traces are processed and compressed into a single file along with any message that the team members want sent back to the main site. Each night, the computer at the main site makes a connection with a computer at a field site. The computer then downloads a compressed file and uploads any messages from project management to the team. Communication between the main and field sites has been by telephone line. As more remote sites (away for populated areas) are surveyed, other means of communications may be necessary. This is a very brief description of the process. There are many operations and interactions between the computer, analyzer, and other components of this system. Work is continuing in all areas of this mock-up to improve the design. Updating software will be necessary along with improved designs for pre-amps and testing other pick-up coils with integral op-amps. Adding a timing input to data recording from WWV with Universal Coordinated Time (UTC) signals will also be necessary.

DAY OF DISCOVERY II

The second annual Day of Discovery was held on Wednesday, October 21, 1992, and proved to be a highly successful event. This year's theme focused on economic recovery through the establishment of triad partnerships with industry, government, and education through the George Washington Carver Partnership concept. The conference was presented in three different segments with the morning session featuring speaker presentations, the afternoon session featuring working groups, and a Uplink broadcast running concurrently. A variety of participation levels was offered throughout the day providing an opportunity for those in attendance to air their concerns and suggestions about local economic conditions.

With the help of the Governor's Office for Aerospace Programs, there was no shortage of qualified speakers anxious to participate in the conference. Representatives from industry, government, and education were present, as well as representatives from similar successful economic development programs. Student and staff involvement in every aspect of the planning stages was gratifying. Involvement included scheduling speakers, designing and producing programs and invitations, making follow-up telephone calls to confirm attendance, and assisting in the audio/visual set-up and implementation. Many helping hands were needed and present NASA Project students and staff, former Project students, past and present Electronic Engineering Technology students, and Community College Division staff all worked together to make the event a success.

The morning session was held in the Wallace Hall Auditorium featuring well-qualified speakers presenting views and experiences about economic development in their specific area. Afterward, the audience had an opportunity to ask questions. The participation and knowledge of the audience contributed to an interesting and informative morning session. (Appendix A)

In the afternoon, working groups were formed containing at least one representative from each of the areas of industry, government, and education to discuss possible partnership development and funding potentials. Later in the day participants in the Uplink program departed to the Community College Division for an EDNET broadcast. (Appendix A)

After the conference, a proposal was submitted by the Community College Division of West Virginia State College to the Joint Commission for Vocational-Technical-Occupational Education to fund the George Washington Carver Partnership. Letters of support from the industrial, governmental, and educational speakers and participants of the Day of Discovery Conference contributed to the successful George Washington Carver Partnership funding grant.

SIR ISAAC NEWTON SCIENTIFIC CONFERENCE

During the period covered by this progress report, Craig Spaniol and John Sutton from the NASA-WVSC project team were invited to present a paper for the International Conference on Sir Isaac Newton held March 22-27, 1993, in St. Petersburg, Russia. The paper presented was titled "G", and focused on a derivation of the Newtonian Gravitational Constant (G) utilizing a model developed to assist research being conducted on resonant frequencies in the Earth-ionosphere cavity for this project. (Appendix C) This paper was well received and this international interaction presented opportunities for our scientists and staff to extend project communication to an international scientific community.

The international scientists present were interested in research being done along with a more general model approach as presented by the three papers which have been published in "Physics Essays" by Dr. Spaniol and Dr. Sutton on "Classical Electron Mass and Fields" Part I, II, and III. Several contacts have continued after the conference to extend and expand communications on the model, and during this conference there was considerable discussion on the subject. During the conference scientists from Russia, England, France, U.S.A, Finland, etc., were focused on the classical physics of Sir Isaac Newton and the gravitational paper fit well into the conference theme. Russians hosting the conference were warm, hospitable and friendly. Dr. Sutton and Dr. Spaniol were included as members of the conference's Scientific and

Local Organizing Committees and assisted as plenary session chairmen in several sessions. (Appendix B)

Certainly Northern Russia in March is not the peak tourist season, but the group who attended the conference were impressed and pleased with the beauty and history of St. Petersburg. The warmth of the Russian people more than made up for any lack from the season. Russian scientists and engineers were found to be very open and receptive to different technical approaches to scientific research. Future interaction should be mutually beneficial. These Russians are well educated in their fields, as well as having a very solid and substantial general knowledge of science, math, and engineering. Because of their separation from Western science during the cold war period, they have often developed different and creative approaches to technological problem-solving. This will become a creative base for growth of science and technology which both countries can utilize through communication and interaction. We feel that our project visit to Russia has assisted this process.

APPENDIX A

Day of Discovery II
George Washington Carver Partnership
October 21, 1992

THE GEORGE WASHINGTON CARVER PARTNERSHIP

A Triad Concept

Exploring the Potentials of Governmental, Industrial, and Educational Partnerships for Industrial Development

Government has responsibility for maintaining the welfare of its citizens. The economic health of any locality depends upon its industrial base and industry depends upon the educational system to produce a trained work force and for technology transfer. The three are synergetic, and one cannot succeed independently without the other two. Therefore, it is necessary to develop a structure in which these three groups can interact and develop partnerships for mutual and individual benefit, leading to industrial development.

Within the Greater Kanawha Valley and West Virginia, in general, these three groups have functioned, too often, independently without the benefit of a sustained combined operation that significantly affects the state's economic status. This paper addresses the situation and proposes the establishment of partnerships that create opportunities to revitalize West Virginia with a productive economy.

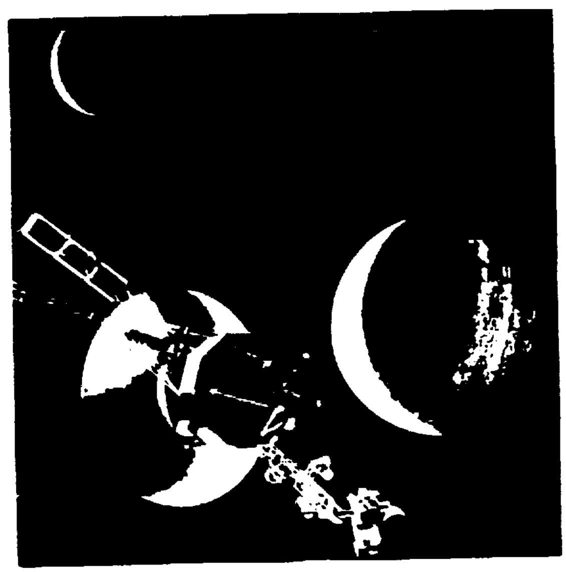
The key to success for developing the structure necessary to produce operational partnerships is the creation of an educational-governmental-industrial team that will develop the support for coordination and operation of partnership activities. Such a structure should be located within an educational institution but should operate independently as do college foundations. West Virginia State College is the logical educational institution for this purpose since it is located in the population, governmental, and industrial center of the state. The specific entity should be entitled the **George Washington Carver Partnership.**

The operational objective at the Corporation is to utilize all available resources to develop innovative technology to establish stable long-term expertise in areas that will enhance the well being of the individual partners. The initial thrust will be in the immediate attraction of federally funded research and development projects in southern West Virginia. The selection of projects should be made with long-term goals and the utilization of short-term projects that enhance long-term programs. The immediate short-term goal is the application of transfer of advance technology, such as aerospace, to existing local business and industries to improve their competitive position. The long-term goal is to attract or internally produce new industries within the state.

Day of Discovery
Wednesday October 21, 1992

George Washington Carver Partnership

Exploring the Potentials of Governmental, Industrial, and Educational Partnerships for Industrial Development



sponsored by

WVSC
NASA-MEIRF
Community College Division
West Virginia Development Office
EDNET/SATNET

MORNING PROGRAM

Wallace Hall - 122
Auditorium

A program of speakers discussing the George Washington Carver triad partnership concept and responding to questions from the audience.

8:30 a.m.	Registration
8:45	Welcome .... Hazo W. Carter, Jr., WVSC President
9:00	Message from the Governor .... Ann Johnson Director, West Virginia Development Office
9:15	Conference Activities .... Craig Spaniol
9:30	Industrial Perspective .... Frank Justice Vice President, Community Affairs, Ashland Oil, Inc., and Chairman, Board of Directors, West Virginia State College Foundation
10:00	Break / Question and Answer Period
10:15	Partnership Programs .... Reed McManigle Director, Business Services/Staff Attorney, Ben Franklin Technical Center, Western Pennsylvania
10:45	Break / Question and Answer Period
11:00	Education ... The Honorable Cecil H. Underwood Chairman, Board of Directors, WV State College System, and President, Software Valley, Inc.
11:30	Question and Answer Period
11:45	Morning Session Close .... Craig Spaniol
12:00 noon	Luncheon at Wilson College Union

AFTERNOON PROGRAM

Held at
Wilson College Union - Banquet Room

Speakers briefly discussing triad partnerships and workshops to experiment with the practical formation of these groupings.

1:00 p.m.	Government Perspective .... Nick Bayne President, Business and Industrial Development Corporation (BIDCO)
1:15	Triad Viewpoint .... Raymond Askew Director, Center for Commercial Development of Space, Space Power Institute, Auburn University
1:30	Afternoon Group Work Session is to initiate partnership development and discuss funding potentials
3:15	Conference Closing .... Nick Bayne

UPLINK SESSION

Broadcast from SATNET/EDNET facilities

A televised panel discussion at 2:00 p.m. of the triad partnership concept with opportunity for public participation through telephoned questions and answers. The program is available in Wallace Hall, Room 122.

DAY OF DISCOVERY

THE GEORGE WASHINGTON CARVER PARTNERSHIP

Exploring the Potentials of Governmental, Industrial, and Educational Partnerships for Industrial Development

Wednesday, October 21, 1992
8:30 a.m. - 3:30 p.m.

MORNING PROGRAM - ROOM 122 WALLACE HALL

8:30 a.m.	Registration
8:45	Welcome ...... Hazo W. Carter, Jr., WVSC President
9:00	Message from the Governor............. Ann Johnson Director, West Virginia Development Office
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12:00 noon	Luncheon at Wilson College Union

AFTERNOON PROGRAM - CONTINUES AT WILSON COLLEGE UNION

1:00 p.m.	Government Perspective................. Nick Bayne President, Business and Industrial Development Corporation (BIDCO)
1:15	Triad Viewpoint......................... Ray Askew Director, Center for Commercial Development of Space, Space Power Institute, Auburn University
1:30	Afternoon Group Work Sessions (2 hours)

AFTERNOON UPLINK PROGRAM (2:00 p.m. - 3:30 p.m. EST) SATNET/EDNET

2:00 p.m.	The UPLINK panel discussion is available on Satellite: GALAXY 2, Transponder 19, Channel 19, and Audio Subcarrier frequencies 6.8 MHz and 6.2 MHz. Antenna orientation is 74 West longitude. The telephone number for questions and answers during the UPLINK program is 1-800-233-3638. For reception technical difficulties call 766-2060.

WEST VIRGINIA STATE COLLEGE, COMMUNITY COLLEGE DIVISION
P.O. Box 1000, Institute, WV 25112
For further information: (304) 766-4123/3118

YOU ARE INVITED TO ATTEND

Day of Discovery

George Washington Carver Partnership

Exploring the Potentials of Governmental, Industrial, and Educational Partnerships for Industrial Development

UP-LINK

A panel discussion of the triad partnership concept with the opportunity for public participation through telephoned questions and answers

WVSC Down Link location:
Wallace Hall Room 122
Wednesday October 21, 1992
2:00 - 3:30 p.m.
Telephone available

WEST VIRGINIA STATE COLLEGE - NASA - MEIRF PROJECT

Community College Division Campus Box 146 P.O. Box 1000 Institute, WV 25112-1000
PHONE: (304) 766-4123/3213 FAX: (304) [redacted] 766-4105
NAG - 5 - 1267

UPLINK PROGRAM
GEORGE WASHINGTON CARVER PARTNERSHIP

The following is a brief discussion of the up-link SATNET/EDNET program scheduled for 2:00 to 3:30 pm EST on October 21, 1992, from the campus of West Virginia State College. The purpose of the program is to provide information about the George Washington Carver Partnership concept and to have an interactive panel discussion to provide opportunity for public input. This will be a general program of discussion to introduce the partnership concept, and time will be available for phone-in questions.

The speakers were selected to develop presentations on understanding of the partnership concept and to provide practical information about the mechanics of participation. Many of the program's goals and procedures have been operational in other geographical areas. The immediate objective is to initiate activity of this type in West Virginia.

Listed below are the scheduled speakers with some details about their perspective and area of expertise:

1. Dr. Anita Lilly, Asst. Dean, Community College Division, West Virginia State College - Will moderate the panel discussion and provide input on partnerships from the perspective of the Community College Division.

2. Mr. Reed McManigle, Director of Business Services/Staff Attorney, Ben Franklin Technology Center, West Pennsylvania- Will provide comment and insight into the operation of economic development partnerships. He will describe some of the methods his organization has utilized to initiate the creation of partnerships, including the key ingredients necessary to form lasting and successful partnership ventures.

3. Dr. Hazo Carter, President, West Virginia State College - Will introduce and host the up-link program from the West Virginia State College campus. He will be discussing the participation of education in the partnership concept as fulfilling the educational missions of research, the education of manpower

for work force participation in an expanded and upgraded industrial marketplace, and the central role of colleges in economic development activity. Dr. Carter will briefly discuss the very positive connection with the historical activities of George Washington Carver, who utilized technology to enhance the economy of an earlier time.

4. Dr. Raymond Askew, Director, Center for Commercial Development of Space, Space Power Institute, Auburn University - Will discuss the needs of industry for the solution of technical and economic problems; the needs for new technology and improved, higher margin products; as well as the need for seed money to initiate research and product development programs. Industry also needs trained, educated employees so that the skilled jobs can be filled by West Virginia residents rather than bringing in out-of-state labor. Presently there is need for technical jobs because many of the better trained and educated employees must leave the state to find suitable employment. This further erodes the base of skilled labor available and the state's ability to develop high technology industry.

5. Dr. Gerald Soffen,Director,University Relations, NASA Goddard Space Flight Center (via Satellite from Ames Space Flight Ctr,California) Will give some general and specific advice for preparing grant proposals and securing contracts. In the triad group, the College has a high probability for success in obtaining funds. This may be the best initial approach for funding of the triad partnerships. Each institution should emphasize the areas where funds are available and where the partnership has its strength and uniqueness. Emphasis on the cooperative approach and the need for follow through will be included.

6. Professor Craig Spaniol, Electronics Engineering Technology and NASA Project Research Principal Investigator, Community College Division, West Virginia State College - Will discuss how to develop and follow through on research proposals, the opportunity for triad partnerships, experiences with federal and state agency cooperation, and the general topic of opportunity for state economic development which benefits all parties and provides employment opportunity for the technical graduates in college programs.

The up-link program will air October 21, 1992, between 2:00 p.m. and 3:30 p.m. EST, on GALAXY 2 Satellite, Transponder 19, Channel 19, and audio subcarrier frequencies 6.8 and 6.2 MHz. Antenna orientation is 74 degrees West longitude. Call-in number for questions is 1-800-233-3638. For technical transmission information or advice call (304) 766-2060.

APPENDIX B

Sir Isaac Newton Scientific Conference
March 22 - March 27, 1993

RUSSIAN ACADEMY OF SCIENCES
RESEARCH INSTITUTE OF RADIO - ELECTRONICAL COMPLEXES
SLAVONIC ACADEMY OF SCIENCES

INTERNATIONAL CONFERECE ON SIR ISAAC NEWTON AND THE PROBLEMS OF MECHANICS OF RIGID AND DEFORMABLE BODIES

MARCH 22-27, 1993, ST.-PETERSBURG, RUSSIA

PROGRAM OF THE CONFERENCE AND ABSTRACTS

SCIENTIFIC ORGANIZING COMMITTEE

Yu. S. OSIPOV, President of Russian Academy of Science
honorary member of the SOC;
S. S. GRIGORIAN, (Russia); Co-Chairman of the SOC;
B. L. MORANDO, Professor; (France); Co-chairman ;

G. T. ALDOSHIN, (Russia); G. G. CHERNI, (Russia); A. DEPRIT, (USA);
Ch. DURR, (Switzerland); V. M. FOMIN, (Russia);
P. N. KROPOTKIN, (Russia); K. V. MANUJLOV, (Russia);
A. A. SHPITALNAYA, (Russia); S. SPANIOL, (USA);
S. A. TOLCHELNIKOVA, (Russia); V. S. YAKOVLEV, (Russia)

LOCAL ORGANIZING COMMITTEE

M. P. VARIN, Chairman;
A. A. SHPITALNAYA, secretary;

R. C. KEYS, (Canada); L. A. KHARKIN; K. V. MANUJLOV; M. N. ROGULEVA;
S. A. TOLCHELNIKOVA; Yu. S. VORONOV; A. A. YEFIMOV.

General sponsor of the conference - Research Institute of Radio-Electronical Complexes,
M. A. GRAMAGIN, Director, St. Petersburg

General manager of the conference - E. Yu. CHEBOTAREVA,
chief manager of MALIK ZEINE Inc, USA.

16:40 V. A. Kuzminykh GLOBAL REGULARIZATION AND REDUCTION OF THE SATELLITE VARIANT OF THREE-BODY PROBLEM

17:20 Discussion 20 minutes

SECTIONS N 2 AND N 3 March, 22 Round Hall

Chairmen: V. V. Brovar, A. V. Shabelnikov, C. Spaniol, J. Sutton

14:00 A. A. Yefimov, A. A. Shpitalnaya PRECESSIVE MOTION OF THE EARTH IN THE NEWTONIAN SPACE

14:20 V. I. Bogdanov GEODYNAMYCAL ASPECTS OF FRACTAL AND FRACTURED EARTH'S CRUST

14:40 V. S. Popov PHYSICAL STRUCTURE OF GRAVITATIONAL CONSTANT

15:00 G. Ja. Vasilyeva, V. A. Kuzmina THE EARTH'S POLAR MOTION AS A SPECIFIC EVIDENCE OF THE EARTH'S SELF - ORGANIZATION IN THE GALAXY

Break 20 minutes

15:40 A. V. Shabelnikov GENERALIZED LAW OF INTERACTION BETWEEN MOVING OBJECTS IN REVOLVING UNIVERSE

16:00 N. A. Chujkova ABOUT TWO OBSERVATIONAL EFFECTS OF THE POSSIBLE MANIFESTATION OF GRAVITY ABSORPTION ON THE EARTH

15:40 A. M. Gurin GEOMETRIC SIMULATION OF STRUCTURAL ELEMENTS OF METALLIC GLASSES

16:00 V. N. Leitzin, V. I. Maslowski, V. A. Skripniak
NEW APPLICATIONS OF MECHANICS IN PRODUCING OF STRUCTURAL MATERIALS

16:20 E. N. Perevoznikov, A. A. Romanova, A. M. Konchakov
DYNAMIC PROCESS IN STRAINED ANISOTROPIC SOLIDS

16:40 A. M. Stalevich, V. G. Tiranov, G. Ja. Slutzker, Z. F. Stalevich, P. P. Rymkevich
NONLINEAR RELAXATION NUCLEI OF HIGHLY ORIENTED SYNTHETIC POLYMERS

17:00 Discussion 20 minutes

SECTION N 2 AND N 3 March, 23 Large Hall

Chairmen: V. I. Bogdanov, N. I. Nevskaja, Ch. Dürr, T. Jaakkola

14:00 C. Spaniol, J. Sutton "G"

14:25 V. V. Brovar, M. V. Pavlov, P. A. Stroev DETERMINATION OF NEWTON GRAVITATIONAL CONSTANT BY GEOPHYSICAL METHOD

14:45 T. Yaakkola THE LAW OF GRAVITY IN SYSTEMS OF DIFFERENT SCALES

2.11 PILYUSHENKO V. V.

ACCRETION CONCEPTION OF SOLAR ACTIVITY

2.12 POPOV V. S.

THE PHYSICAL STRUCTURE OF GRAVITATIONAL CONSTANT

Gravitational constant was introduced into physics in 1687 by I. Newton, who formulated the law of gravitation in his famous "Mathematical principles of natural philosophy". Nevertheless in spite of progress of modern theoretical and experimental physics, the theory of gravitation is still incomplete, what could be explained probably by extraordinary complexity of the problem. The attempt is made to involve the hypothesis of a certain finite speed of gravitation, which has been published by the author in 1985.

2.13 SPANIOL C., SUTTON J.

"G"

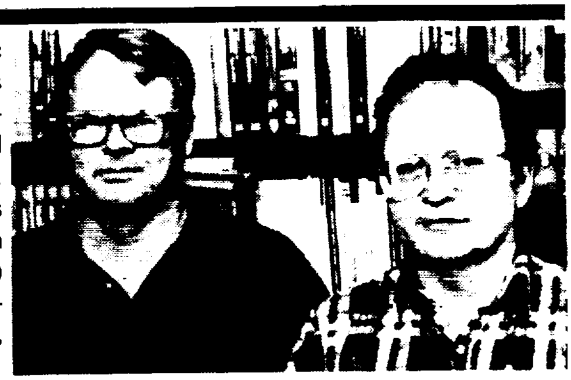
This paper describes a derivation of an algebraic relationship between the Newtonian gravitational constant (G) and other experimentally determined physical constants. The technique involves an electrical circuit approach and includes the principles of resonance, power, energy, action, and Doppler frequency shift. The calculated numerical result is in agreement with the currently accepted (CODATA) mean value at the 11 ppm level of precision which is an order of magnitude greater than the listed level of precision (128 ppm).

GRANTS UPDATE

Office of Grants and Research
Division of Planning & Institutional Advancement
West Virginia State College

Volume I, No. 5

April 8, 1993



Among the 150 scientists at the International Conference on Sir Isaac Newton, sponsored by the Russian Academy of Sciences, were representatives from WVSC's NASA project (also known as Magnetic Earth Ionosphere Resonant Frequencies). Principal Investigator of the project, Dr. Craig Spaniol, Carl Anderson and John Sutton, were invited to attend the conference in St. Petersburg, Russia, to present a paper based on theoretical developments which came out of the NASA investigations. This paper describes a derivation of an algebraic relationship between the Newtonian gravitational constant (G) and other experimentally determined physical constants. The technique involves an electrical circuit approach and includes the principles of resonance, power, energy, action, and Doppler frequency shift.

Attendance at the Newton Conference is only the most recent of the NASA project's accomplishments, which considers one of its most significant achievements to be the involvement of more than 40 students in hands-on research experience. The project had three papers presented at the International Tesla Symposium in Colorado Springs, and has had two papers published in the international journal *Physics Essays,* with a third to be published this fall.

Congratulations to the entire staff of the NASA project on their accomplishments.

Below is a list of upcoming application deadlines for federal funding opportunities. Please refer to the number in parentheses when requesting further information from the Office of Research and Grants, Debra Martin (ext. 3026).

Math, Science, and Engineering

Academic Research Enhancement Grants (NIH) support applications to stimulate biomedical studies at institutions that are not research intensive but provide baccalaureate training for a significant number of research scientists. Due June 18. (#0602)

Minority Predoctoral Fellowships (NIGMS) support individual minority predoctoral research training fellowships leading to the PhD, combined MD/PhD degrees or other combined professional-research doctorate degrees in the biomedical sciences. Due April 27. (#0404)

Small Business Innovation Research Grants (DoT) support projects to conduct feasibility-related experimental or theoretical research or R&D efforts on certain research topics. Due May 3. (#0503)

Planetary Geology and Geophysics Grants (NASA) support basic research proposals in planetary geology, geophysics, remote sensing, cartography and geologic mapping. Due April 15. (#0410)

Teacher Enhancement Grants (NSF) support projects to develop effective approaches and creative materials for the continuing education of elementary, middle and secondary school mathematics and science teachers. Due Feb. 1 and Aug. 1. (#1317)

Informal Science Education Grants (NSF) support projects outside school that will give people of all ages an understanding of science, mathematics and their applications. Due Feb. 1 and Aug. 1. (#1316)

Exploratory Environmental Research Grants (EPA) support projects to conduct exploratory environmental research in biology, chemistry, physics, engineering and socioeconomics. Due Feb. 1 and Aug. 2. (#1312)

Pollution Prevention Grants (DoE and EPA) support new industrial processes and/or equipment that can significantly reduce wastes in industry, improve energy efficiency and enhance the competitiveness of U.S. industry. Due April 30. (#0402)

Health

Environmental Health Sciences Centers (NIGHS) support projects to establish multidisciplinary research programs that use state-of-the-art science to study the environmentally related health problems of economically disadvantaged and underserved populations. Due June 1. (#0603)

Health Promotion in Older Minority Populations Grants (NIA) support exploratory centers to conduct pilot research and plan for a program of medical, behavioral and social research, medical and psychosocial interventions, and health education and community outreach programs to improve the health of older ethnic minority populations. Due April 19. (#0413)

Research on Rural Health Services Grants (AHCPR) support new research on delivering, organizing and financing rural health services. Due Feb. 1, June 1, and Oct. 1. (#1303)

Behavior Change and Prevention Strategies to Combat AIDS Grants (NIH) support projects which study behavior change and prevention strategies to reduce transmission of HIV. Due Jan. 2, May 1, Sept. 1. (#1309)

Behavioral Sciences Research Grants (ONR) support projects on manpower, personnel and training issues grounded in applied behavioral science research. Applicants may submit proposal through Jan. 1994. (#1321)

Liberal Arts and Education

Economic Development in Egypt Grants (AID) support collaborative research in agricultural development and food production, industry, energy, human resource development and education, infrastructure, economic development and environmental studies. Due April 15. (#0415).

METRO West
Gazette-Mail
Putnam Edition
April 21, 1993

Earth vibrations being studied

By Eric Douglas
METRO STAFF

Whether or not they can be used to control the minds of enemy soldiers or predict quakes in the earth's crust, Craig Spaniol thinks the low frequency vibrations that surround the earth need to be studied.

Spaniol is a professor of Electrical Engineering and the principal Investigator for the NASA project at West Virginia State College.

The NASA project is a grant awarded by the space agency to study low frequency waves in and around the earth.

As Spaniol described it, the earth is ringing like a bell at very low frequencies. The frequencies are below normal hearing and normal radio detection, but "advances in computer technology have allowed us to be able to monitor changes in these frequencies," he said.

Now Spaniol — along with Carl Anderson, project manager and John Sutton from the Goddard Space Flight Center in Maryland — is working to develop a low frequency receiving station to monitor the frequency waves.

In spite of the research Spaniol and partners have done at the school, he said they have not committed their study to one application. They have been in contact with other schools and research agencies who may be able to use their information.

"There is a strong interest in monitoring changes in these low end signals in earthquakes, like in Oakland," he said. "There was some evidence of changes in these signals before the big earthquake."

An interesting twist for the research Spaniol is doing is that the frequency ranges are the same frequency as human brain waves.

"If you raise the brain wave, would a person become agitated? If you lower it, would the person fall asleep? Those are questions that are being asked," Spaniol said.

He noted that there were reports of the Soviets investigating brain waves for mind control, but those have been unsubstantiated.

"I am not sure if there is even any correlation between brain waves and the earth frequency but it is an obvious parallel to draw," he said.

To distribute their findings to the scientific community, the group of researchers recently traveled to St. Petersburg, Russia to participate in the International Conference on Sir Isaac Newton.

The study was well received and Spaniol said he sees more possible connections between the scientific communities in West Virginia and Russia.

"The problems the Russians have are similar to what we have in West Virginia," he said. "I think we have a good chance at understanding the Russians."

Spaniol explained the Russians have a tremendous technical base but, because of the economic collapse they stand to lose a lot of their best and brightest people. They will go where they can find work and that will be some other country in need of rocket or nuclear technology.

Of West Virginia, Spaniol said the industry and the people are here but "we do not have a research/education center to hold the business, industry and community together."

He said he would like to begin interactive research with the Russians.

"We have got to have a technological recovery here and it is not happening. The existing institutions are not taking on the initiative to make it work," he said.

Spaniol said he would like to establish the joint facility at State College that could benefit the Russians, the college and the state.

"Our federal government sees the need to provide funding to get the Russians over the hump," he said. "If we could develop an interactive research facility, it would not be hard to get federal money."

APPENDIX C

- G -

This paper was presented at the Sir Isaac Newton Conference in St. Petersburg, Russia. It contains some of the results of our investigation of fundamental frequencies that are inherent within the electron's physical structure. In essence, the Newtonian Gravitational Constant, G, can be calculated using the HYDRA model developed as an electrical model of the electron.

G

Craig Spaniol, WVSC, and John F. Sutton, NASA - GSFC

Summary

This paper describes a derivation of an algebraic relationship between the Newtonian gravitational constant (G) and other experimentally determined physical constants. The technique involves an electrical circuit approach and includes the principles of resonance, power, energy, action, and Doppler frequency shift. The calculated numerical result is in agreement with the currently accepted (CODATA) mean value at the 11 ppm level of precision which is an order of magnitude greater than the listed level of precision (128 ppm).

BACKGROUND

Over the past several years, a model of the electron has been developed that appears promising in the ability to understand and calculate particle masses.[1,2,3] One of the interesting direct results was the algebraic relationship presented in this paper. This model, named HYDRA, includes gravitational energy and represents the mass system as an electrical circuit. It was initially developed as a method of estimating natural frequencies that may appear in the upper ionosphere due to electron excitation. It has developed into a detailed model of electron structure and has been partially extended into general lepton structure. This paper focus on what is termed the zero order or non-rotational equations. The higher order section of the model deals with magnetic and inertial properties. As time and funding permit, work will continue on this most interesting subject.

HYDRA MODEL

The methods employed and present state of model development are described in the three referenced **Physics Essays** journal articles on this subject. Relativistic Doppler, quantum (resonance) and electrical circuit concepts are the central theme of the HYDRA model development. All physical properties are reduced to electrical circuit equivalent representations and result in circulating electric currents associated with their respective resonant circuit. For example, the electrical, gravitational, and spin systems are uniquely defined by individual currents and frequencies. The fundamental assumptions or hypotheses associated with the HYDRA model are:

1. Gravitational energy is not excluded. Electric, magnetic and gravitational field interactions are not included directly. They are implicit within the current frequencies.

2. Both the electric and gravitation systems are modeled as coupled resonant circuits with associated power, energy and action values. Cross-flow power is an integral part of the model.

3. Currents are defined by ef. Frequencies are defined by V/λ. Frequency shifts due to velocity frame differences are defined by the relativistic Doppler shift. Frequencies are referenced to the electron's rest frame (zero linear velocity).

4. The electron is modeled with radial (zero order) and azimuthal (higher order) motion (frequency).

5. Quantum concepts are included. Action (h), energy (hf) and power (hff) are assumed to be quantized. Electron spin action is assumed to be $\hbar/2$.

These currents are similar to the generalized Dirac current (j_μ) which is an integral component of the classical relativistic Lorentz-Dirac equation for a charged particle. This classical Dirac approach was extended by others to include a self-field interaction term generated with quantum field concepts. The identification of the radiation reaction term with the anomalous magnetic moment interaction is implicit in quantum field theory. A cross-field coupling term was developed which interlocks self-energy with an anomalous magnetic moment (Pauli) interaction. The end result is that the radiation reaction term in the classical relativistic Lorentz-Dirac equation ($2\alpha/3$) can be recalculated with QED principles to produce the more correct value of $\alpha/2\pi$. The HYDRA approach does not address such interactions directly. However, any such interactions will manifest as small frequency shifts or deviations in the HYDRA derived currents ($I = ef$). In other words, the QED corrections to the electron magnetic moment anomaly will appear as a small correction to the Doppler shifted HYDRA frequencies. This frequency correction is derived from the experimental value for the moment anomaly. Because the experimental anomaly value and the QED derived value are identical, one could use the QED value to find the HYDRA currents and the results would also be identical. Since HYDRA currents are directly related to electron mass, both HYDRA and QED derived corrections can be represented as small mass variations.

The basic zero order (radial) HYDRA equation simply states the algebraic relationship that must hold between electron mass, gravitation constant, magnetic moment anomaly, h, α, and electron charge. The physical process (such as virtual particle charge shielding) that produces the magnetic moment anomaly is not necessary to identify within the HYDRA development as such effects enter the model in the form of an input experimental value. Therefore they are included within the relativistic Doppler effect. While the HYDRA model is a simple approach, its initial contribution to science is that it includes gravitational effects (G), which are 10^{40} times less than electrical, and demonstrates that they are directly related through the electron's spin (cross-coupling) system. The resultant zero order equation yields an algebraic relationship between G and other experimentally determined physical constants. The Newtonian gravitation constant is an integral component of the HYDRA model which cannot exist without it. For example, f_2 (gravitational current frequency) can be calculated without G in terms of α, h, and C without producing any new knowledge. But by calculating f_2 in terms of the gravitational self-energy or gravitation constant (G), the two independent simultaneous equations for f_2 produce new knowledge in the form of an algebraic relationship between G, α, h, and C. This is the heart of the HYDRA development and G cannot be neglected without nullifying the entire concept.

The zero order equations can be produced or summarized by the following approach where the magnetic moment is represented as a relativistic Doppler shift.

$$\mu_B = eh/(4\pi m_e) \tag{1}$$

and

$$\mu_e = eh/(4\pi m_e') \tag{2}$$

so that

$$\mu_e/\mu_B = m_e'/m_e. \tag{3}$$

Since

$$m_e = hf_e/C^2 \tag{4}$$

and

$$m_e' = hf_e'/C^2 \tag{5}$$

then

$$\mu_e/\mu_B = f_e/f_e' \tag{6}$$

or

$$[\mu_e/\mu_B]f_e' = f_e. \tag{7}$$

Therefore the quantity μ_e/μ_B may be interpreted as a Doppler frequency shift factor with associated velocity frame difference of KC or

$$\mu_e/\mu_B = [\{1 + (KC/C)\}/\{1 - (KC/C)\}]^{1/2}. \qquad (8)$$

The calculated radial velocity of the electron is derived in the journal articles and is simply the ratio of the classical electron radius divided by the Compton wavelength or

$$V = [r_e/\lambda_C]C = [\alpha/2\pi]C. \qquad (9)$$

Therefore, in the first approximation,

$$K = V/C = \alpha/2\pi \qquad (10)$$

and

$$\mu_e/\mu_B \simeq [1 + (\alpha/2\pi)]/[1 - (\alpha/2\pi)^2]^{1/2} \simeq 1 + \alpha/2\pi. \quad (11)$$

This result indicates that the approach is reasonable, but that K is not identically equal to $\alpha/2\pi$. The true value of K can be calculated directly from the μ_e/μ_B experimental value or from the QED corrected calculated value for μ_e/μ_B (these two values are identical). Either produces

$$K = 1.158\ 979\ 792 \cdot 10^{-3} \qquad (12)$$

which results in a shifted frequency unit of

$$f_{uHz} = [(\alpha/2\pi)/K][1\ Hz] = 1.002\ 096\ 671\ Hz \tag{13}$$

and proceed with the HYDRA development within the frequency shifted system. This value is in good agreement with the detailed HYDRA derivation at the ppb level of precision and QED effects are now implicit within f_{uHz} and the HYDRA model. The exact formulation of f_{uHz} is given by

$$[\mu_{e/\mu B} - \mu_B/\mu_e]f_{uHz} = [\{(1+\alpha/2\pi)/(1-\alpha/2\pi)\}^{1/2}$$

$$- \{(1-\alpha/2\pi)/(1+\alpha/2\pi)\}^{1/2}]1Hz \tag{14}$$

or

$$f_{uHz} = [(\alpha/2\pi)/K][1\ Hz][\{1-K^2\}^{1/2}]/[\{1-(\alpha/2\pi)^2\}^{1/2}] \tag{15}$$

which also yields at the 2 ppb level of precision

$$f_{uHz} = 1.002\ 096\ 673\ Hz. \tag{16}$$

The basic timing or frequency unit of the electron is created within the azimuthal system. The azimuthal system must operate at the same base frequency as the radial system (C/λ_C) which sets the azimuthal (tangential) velocity at αC. The azimuthal motion, when projected on a fixed diameter, moves away from the center for a half cycle and toward the center for the other half. The base frequency or timing (since time is the inverse of frequency) unit is created by this motion through the relativistic Doppler shift or

$$f_u = \{(1+\alpha)/(1-\alpha)\}^{1/2} f_{uHz} - \{(1-\alpha)/(1+\alpha)\}^{1/2} f_{uHz} \quad (17)$$

and

$$f_u = 2\alpha f_{uHz}/(1-\alpha^2) = 2\alpha f_{uHz} + \alpha^3 f_{uHz} + \cdots \quad (18)$$

where

$$f_{u0} = 2\alpha f_{uHz} \quad (19)$$

$$f_{u1} = \alpha^3 f_{uHz}. \quad (20)$$

This zero order frequency unit can be used to develop a quanta of cross-power from spin action or

$$P_x = \mathbf{Aff} = [\bar{h}/2][2\alpha f_{uHz}]^2. \quad (21)$$

HYDRA treats the electron at the zero order level as two coupled resonant circuits. These circuits contain self-energy (hf_1, hf_2) and a cross-power (P_x) between them. The power equations for this circuit arrangement are

$$P_1 = I_1^2 Z_1 \quad (22)$$

$$P_2 = I_2^2 Z_2 \quad (23)$$

$$P_{12} = P_x = 2I_1 I_2 Z_{12}. \quad (24)$$

Since the circuits are resonant, the impedances reduce to pure or free space resistances. For the closed circuit cross-power equation ($I = ef$),

$$P_x = 2[ef_1][ef_2][(\mu_o/\varepsilon_o)^{1/2}/(2\pi)]. \tag{25}$$

The value of f_1 is the Compton frequency or

$$f_1 = C/\lambda_C = [m_e C^2]/h \tag{26}$$

and f_2 is obtained from the gravitation self-energy or

$$f_2 = [m_e^2 G/r_e]/h. \tag{27}$$

The electron cross-power is then calculated as

$$\mathbf{P_x = 2[eC/\lambda_C][e(m_e^2G/r_e)/h][(\mu_o/\varepsilon_o)^{1/2}/(2\pi)].} \tag{28}$$

Setting the two equations for cross-power equal produces

$$2[(m_e^3C^2G)/(h^2r_e)] = \alpha f_{uHz}^2 \tag{29}$$

or

$$2[(m_e^3C^2G)/(h^2r_e)] = \alpha[(\alpha/2\pi K)(1\ \mathrm{Hz})]^2 \tag{30}$$

which yields the following relationship for G

$$G = [h^2 r_e \alpha^3 (1\ \mathrm{Hz})^2]/[8m_e^3\pi^2C^2K^2] \tag{31}$$

or

$$G = 6.672\ 527\ 5 \cdot 10^{-11}\ \ m^3/kg \cdot sec^2. \qquad (32)$$

The mathematics used to date are basic algebra and trigonometry. Spherical harmonic techniques following Schrodinger wave mechanics and matrix algebra after the Heisenberg approach are anticipated as the next level of sophistication. Probably a review of Einstein's general relativity and an extension into tensor mathematics as well as non-Euclidean geometry will be required, but the work is in too early a stage to determine the highest level or appropriate applied methods. A principal method for determining validity of the HYDRA research will be the establishment of equivalence between the model results with currently accepted theories of gravity, nuclear, and atomic physics. Likewise, the work cannot become bogged down in any one area. QED calculations for the electron magnetic anomaly appear to be a life-long task. However, the application of the HYDRA model to a potential anomaly in the electron-positron magnetic moment anomalies appears to be a very significant application. At present, there is no intention to expand the HYDRA results to cosmology, although someone will probably do this.

The experimental approach taken for this work is simple and straightforward. It involves the construction of a spherical model of the electron. It will resemble a spherical capacitor or resonant cavity that will be excited at various frequencies to confirm the cross-coupling calculations of electron currents. This work will resemble earlier work done on waveguides and transmission lines. Such work was not done on spherical models since they are difficult to construct and have limited application to engineered communication systems. It is much easier and cost effective to build linear wave guides and cylindrical resonators than spherical ones. In fact, it was not until the middle of this century that theoretical calculations were developed for a spherical resonator by Schumann. He was interested in the earth-ionosphere cavity resonant frequencies and needed a theoretical model. Indeed, the principal cavity resonances are titled, "Schumann resonances." The mathematics is similar to the wave mechanics approach in quantum mechanics, but this work was never directly associated with the concept of a spherical resonator. It was a "normalized wave equation," and the electron was described as a fuzzy ball without structure. Electrical applications, such as microwave theory, had not been developed at that time; and there was no physical example to compare the quantum work with except the Bohr planetary model. Currently, there are no extensive experimental data available on spherical resonators. The instrumentation that will be employed will be modern off-the-shelf units, and the techniques will be similar to those used previously on linear or cylindrical waveguides.

SUMMARY

The HYDRA model has produced an algebraic relationship between G and the other fundamental physical constants of nature. It holds the promise of producing other important physical relationships such as the direct calculation of particle masses. The present level of calculational accuracy is two orders of magnitude greater than the current level of precision given for the gravitational constant. High precision experimental data on the value of G are essential to the further development of HYDRA.

REFERENCES

1. "Classical Electron Mass and Fields", **Physics Essays,** Volume 5, Number 1, March 1992, pp. 61-69.

2. "Classical Electron Mass and Fields II", **Physics Essays,** Volume 5, Number 3, September 1992, pp. 429-447.

3. "Classical Electron Mass and Fields III", **Physics Essays,** Volume 6, Number 2, June 1993, (pending).

Condensed G

Given

λ_C, the Compton wavelength ($\lambda_C = h/m_eC$), and r_e, the classical electron radius ($r_e = (\alpha/2\pi)\lambda_C$), f_C, the Compton frequency is given by

$$f_C = m_eC^2/h = C/\lambda_C = e^2/h4\pi\varepsilon_o r_e = e^2/h2\pi\varepsilon_o(\alpha/2\pi)\lambda_C. \quad \text{(A1)}$$

Similarly, f_g, the gravitational frequency, is given by

$$f_g = E_g/h = [m_e^2G/r_e]/h = [m_e^2G/(\alpha/2\pi)\lambda_C]/h \quad \text{(A2)}$$

Propose that the following quantities can be calculated with A, an action quantum unit.

$$E = Af \quad \text{Energy} \quad \text{(A3)}$$

$$P = Aff \quad \text{Power (self)} \quad \text{(A4)}$$

$$P_x = 2Af_1f_2 \quad \text{Power (cross or coupled)} \quad \text{(A5)}$$

Set electron Electric-Gravitation cross-power, P_x, equal to electron spin-power, P_s.

$$h = e^2/2\alpha\varepsilon_o C \quad \text{Planck action quantum} \qquad (A6)$$

$$A_e = e^2/\varepsilon_o C \quad \text{Electron action quantum} \qquad (A7)$$

$$A_e/2\alpha = h \qquad (A8)$$

$$P_x = P_s$$

$$2[A_e/2\pi][f_C/2\alpha][f_g/2\alpha] = [\bar{h}/2]f_x^2 \quad \text{Planck frame} \qquad (A9)$$

or,

$$2\bar{h}f_C f_g = [(1/2)(A_e/2\pi)]f_x^2 \quad \text{Electron frame} \qquad (A10)$$

f_x is a unit frequency that produces one unit of spin energy and power. Note that f_x is approximately one Hertz. Thus,

$$\boxed{2f_C f_g = \alpha f_x^2} \qquad (A11)$$

Obtain f_x from μ_e/μ_B by assuming that μ_e/μ_B is generated by Doppler shift or,

$$\mu_e/\mu_B = [(1 + \beta)/(1 - \beta)]^{1/2} \; ; \; \beta = V/C \qquad (A12)$$

Since $f_C = (\alpha/2\pi)C/r_e$; $\beta_{cal} = \alpha/2\pi$ and set $\beta_{expt} \equiv k$.

$$[\mu_e/\mu_B]_{cal} = [(1 + \alpha/2\pi)/(1 - \alpha/2\pi)]^{1/2}$$

$$= 1.001\ 162\ 085\ 011\ 39 \qquad (A13)$$

$$[\mu_e/\mu_B]_{expt} = [(1 + \beta)/(1 - \beta)]^{1/2}$$

$$= 1.001\ 159\ 652\ 188\ 4 \qquad (A14)$$

where

$$\beta_{expt} = k = 1.158\ 979\ 792\ 252 \cdot 10^{-3} \qquad (A15)$$

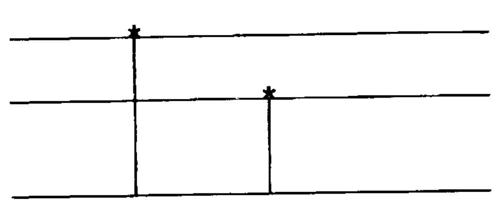
and

$$\alpha/2\pi = 7.297\ 352\ 934\ 8 \cdot 10^{-3}/2\pi$$

$$= 1.161\ 409\ 791\ 06 \cdot 10^{-3} \qquad (A16)$$

Derive f_x ; $f_x = f_{uHz}$

The calculational, $[\mu_e/\mu_B]_{cal}$, frame is characterized by velocity $(\alpha/2\pi)C$ while the experimental, $[\mu_e/\mu_B]_{expt}$, frame is characterized by velocity kC.



	Velocity	unit frequency
	$(\alpha/2\pi)C$	1 Hz
	kC	f_{uHz}
	common reference frame (0)	

Find the value for f_{uHz} such that numerical values are compatible or are referenced to the common measurement and calculational frame.

1^{st} approximation (non-relativistic), set

$$f_{uHz}/(1\ \mathrm{Hz}) \simeq (\alpha/2\pi)C/kC = \alpha/2\pi k = 1.002\ 096\ 671 \qquad \text{(A17)}$$

which is accurate to 2 ppb. Now relativistically correct for length contraction or

$$f_{CHz} = [(\alpha/2\pi)C]/[\{1 - (\alpha/2\pi)^2\}^{1/2} r_e] \qquad \text{(A18)}$$

$$f_{CuHz} = [kC]/[\{1 - k^2\}^{1/2} r_e] \qquad \text{(A19)}$$

$$f_{uHz}/(1\ \mathrm{Hz}) = f_{CHz}/f_{CuHz}$$

$$= [\alpha/2\pi k][\{1 - k^2\}/\{1 - (\alpha/2\pi)^2\}]^{1/2}$$

$$= 1.002\ 096\ 673\ 382\ 554 \qquad \text{(A20)}$$

$$\boxed{f_{uHz} = [\alpha(1\ \mathrm{Hz})/(2\pi k)][\{1 - k^2\}/\{1 - (\alpha/2\pi)^2\}]^{1/2}} \qquad \text{(A21)}$$

$$\boxed{\boxed{G = (\alpha f_{uHz})^2 \lambda_C^4 C/(4\pi h) = 6.672\ 527\ 5 \cdot 10^{-11}\ \mathrm{m}^3/\mathrm{kg} \cdot \mathrm{sec}^2}}$$

Alternate Derivations

Find the proper unit frequency (f_{uHz}) for the experimental reference frame in terms of the calculational frequency unit (1 Hz).

$$[\mu_e/\mu_B]_{cal} = [(1 + \alpha/2\pi)/(1 - \alpha/2\pi)]^{1/2}$$

$$= 1.001\ 162\ 085\ 011\ 39 \qquad \text{(A13)}$$

$$[\mu_e/\mu_B]_{expt} = [(1 + \beta)/(1 - \beta)]^{1/2}$$

$$= 1.001\ 159\ 652\ 188\ 4 \qquad \text{(A14)}$$

where

$$\beta_{expt} = k = 1.158\ 979\ 792\ 252 \cdot 10^{-3} \qquad \text{(A15)}$$

and

$$\alpha/2\pi = 7.297\ 352\ 934\ 8 \cdot 10^{-3}/2\pi$$

$$= 1.161\ 409\ 791\ 06 \cdot 10^{-3} \qquad \text{(A16)}$$

Set the Doppler-up and Doppler-down frequency unit differences equal to establish a common reference frame.

$$[\mu_e/\mu_B]_{expt} \cdot f_{uHz} - [\mu_B/\mu_e]_{expt} \cdot f_{uHz}$$

$$= [\mu_e/\mu_B]_{cal} \cdot (1\ \text{Hz}) - [\mu_B/\mu_e]_{cal} \cdot (1\ \text{Hz}) \qquad \text{(B1)}$$

$$\{[\mu_e/\mu_B]_{expt} - [\mu_B/\mu_e]_{expt}\}\cdot f_{uHz}$$

$$= \{[(1 + \alpha/2\pi)/(1 - \alpha/2\pi)]^{1/2}$$

$$- [(1 - \alpha/2\pi)/(1 + \alpha/2\pi)]^{1/2}\}\cdot(1\ \mathrm{Hz}) \quad \text{(B2)}$$

$$f_{uHz} = (\alpha/\pi)(1\ \mathrm{Hz})/$$

$$\{[(\mu_e/\mu_B)_{expt} - (\mu_B/\mu_e)_{expt}][1 - (\alpha/2\pi)^2]^{1/2}\} \quad \text{(B3)}$$

$$\boxed{f_{uHz} = [\alpha(1\ \mathrm{Hz})/(2\pi k)][\{1 - k^2\}/\{1 - (\alpha/2\pi)^2\}]^{1/2}} \quad \text{(A21)}$$

---

second alternate derivation

If $2f_C f_g = \alpha f_x^2$, then μ is given by

$$\mu = [(Ch)/2\pi][(G\pi\varepsilon_o^2 C)/(hf_x^2)]^{1/4} \quad \text{(B4)}$$

or

$$f_x = [(Ch)/(2\pi\mu]^2[(G\pi\varepsilon_o^2 C)/h]^{1/2} \quad \text{(B5)}$$

and, since $\mu_e \neq \mu_B$, there are two values for f_x; f_e and f_B.

$$f_B = [(Ch)/(2\pi\mu_B]^2[(G\pi\varepsilon_o^2 C)/h]^{1/2} \quad \text{(B6)}$$

$$f_e = [(Ch)/(2\pi\mu_e]^2[(G\pi\varepsilon_o^2 C)/h]^{1/2} \quad \text{(B7)}$$

Therefore,

$$\boxed{f_B/f_e = [\mu_e/\mu_B]^2} \tag{B8}$$

Doppler shift the difference $(f_B - f_e)$ into the common reference frame or

$$[(1 + \alpha/2\pi)/(1 - \alpha/2\pi)]^{1/2}[f_{BHz} - f_{eHz}]$$

$$= [(1 + k)/(1 - k)]^{1/2}[f_{BuHz} - f_{euHz}] \tag{B9}$$

$$[(1 + \alpha/2\pi)/(1 - \alpha/2\pi)]^{1/2}[f_{BHz} - \{(1-\alpha/2\pi)/(1+\alpha/2\pi)\}f_{BHz}]$$

$$= [(1 + k)/(1 - k)]^{1/2}[f_{BuHz} - \{(1 - k)/(1 + k)\}f_{BuHz}] \tag{B10}$$

$$[\{(1 + \alpha/2\pi)/(1 - \alpha/2\pi)\}^{1/2} - \{(1-\alpha/2\pi)/(1+\alpha/2\pi)\}^{1/2}]f_{BHz}$$

$$= [\{(1 + k)/(1 - k)\}^{1/2} - \{(1 - k)/(1 + k)\}^{1/2}]f_{BuHz} \tag{B11}$$

and since $f_{uHz}/(1\ \mathrm{Hz})$ must equal f_{BHz}/f_{BuHz}

$$\boxed{f_{uHz} = [\alpha(1\ \mathrm{Hz})/(2\pi k)][\{1 - k^2\}/\{1 - (\alpha/2\pi)^2\}]^{1/2}} \tag{A21}$$

APPENDIX D

- A BROAD-BAND ACTIVE ANTENNA FOR ELF MAGNETIC FIELDS -

This article contains the results of our research into high efficiency low frequency receiving antennas. The work involves a principle of activation or re-generation in order to increase a receiving antenna's electromagnetic cross-section. This novel approach has potential application in the communication industry.

A Broadband Active Antenna for ELF Magnetic Fields

John F. Sutton and G. Craig Spaniol

Abstract

A unique broadband ULF-ELF magnetic antenna is described. Active circuitry is employed to introduce a negative impedance that combines with the wire resistance, the distributed winding capacitance, and the inductance of a physically small search coil to produce an antenna with a very small impedance. The result is increased search coil current and an enhanced dipole-plane wave field interaction, which greatly increases the effective area of the antenna, independent of frequency – a "black hole" antenna.

Key words: antenna, active antenna, broadband antenna, ELF antenna, magnetic antenna, Earth-ionosphere cavity, negative impedance, black hole

1. INTRODUCTION

A radio-receiving antenna is usually thought of as a *resonant* electrically conducting structure, tuned to a specific narrow band of wavelengths. Tuning serves the purpose of enhancing the response of the antenna to the desired signals, relative to the response to signals and noise at other wavelengths. The active antenna described here, which exploits an often overlooked field-interaction phenomenon, is believed to be unique in that it was designed with entirely the opposite goal: to provide a miniature *nonresonant* antenna with high sensitivity while operating over a broad band of wavelengths. We describe the plane electromagnetic wave-dipole resonant field interaction, which has been repeatedly discovered and forgotten over the past seventy-five years by the physics community, and an untuned extension of this interaction which we apply to ULF-ELF magnetic field measurements. The engineering aspects, including detailed antenna design and measurements of performance, will be presented elsewhere.

The authors are currently developing a receiving station to monitor the naturally occurring electromagnetic excitations of the Earth-ionosphere cavity resonances in the ULF-ELF frequency bands, nominally in the two decades of frequency between 1 Hz and 100 Hz.(1) It is expected that the data accumulated may provide valuable information about the ionosphere and the energy sources that excite the resonances. For example, because the Earth-ionosphere cavity resonance frequencies depend somewhat on the effective height of the ionosphere, our data acquisition system will be capable of monitoring the fast fluctuations, with periods as short as a few seconds, of the effective height of the ionosphere. It may also be possible to apply the ULF data to the prediciton of seismic activity.(2, 3) Because it is desired to monitor the magnetic field over the entire range of frequencies from 1 Hz – 100 Hz, data analysis will be performed with a fast-fourier transform (FFT) spectrum analyzer. FFT analyzers, such as the Hewlett-Packard model 3582A, 35660A, or 35665A, can accept information simultaneously over a broad band of frequencies and have the ability to resolve periodic components separated by as little as 1/4 Hz over a 100-Hz span.(4) This implies that the magnetic field sensor (antenna) should be untuned and should preferably have a uniform response over the frequency range of interest. In order to achieve sensitivity sufficient to receive the cavity resonance signals, which have magnitudes on the order of one picotesla, such magnetic field sensors traditionally have been large and heavy. Hill and Bostick,(5) for example, used search coils of 30 000 turns of wire wound on high permeability cores of length 1.83 m, weighing 40 kg. In order to make the sensors small and compact for portable field use, it was decided to depart from this customary design practice and to employ active circuitry instead.

2. ACTIVE ANTENNA DESIGN

We wish to discuss an extension of a known physical interaction between plane electromagnetic waves and resonant magnetic "dipole" antennas. By its very nature the plane wave-resonant dipole interaction is a narrow band phenomenon. Our extension consists of producing this same physical interaction over a broad band of frequencies, and applying this interaction, in the form of a broadband active antenna, to a study of the natural excitations of the Earth-ionosphere cavity.

Active antennas, by which we mean antennas that incorporate active circuitry to significantly alter the way the antenna elements interact with the incident electromagnetic field, were employed extensively during the first three decades of this century in VLF, LF, and broadcast band radio receivers. Some receivers simply employed a coil as an antenna and achieved remarkable sensitivity, particularly if the coil was of large diameter. The capacitive reactance of a tuning capacitor balanced the inductive reactance of the antenna coil, and positive feedback ("regeneration" or "reaction") was added to introduce negative resistance, which offset the real positive wire resistance of the coil. The result was a parallel resonant antenna coil circuit with an extremely small impedance at the resonant frequency. The mechanism by which such an antenna attains exceptional sensitivity is generally not understood or appreciated. The low circuit impedance permitted a large circulating current to flow when the coil was excited by an incoming signal field. This large current caused the generation of a dipole electromagnetic field. The dipole field, in turn, interacted with the incident plane wave field in such a way that energy was funneled from a relatively large area of the wave front into the antenna coil.

The history of the discovery and rediscovery of this field interaction phenomenon is a curious footnote in the history of physics. The first known description of the interaction between the field of a plane electromagnetic wave and a dipole field is that given by Rudenberg[6] in 1908. Fleming[7] apparently was unaware of Rudenburg's earlier work when he published a paper in 1932, in which he related the story of a French naval officer, M. Camille Tissot, who made measurements with a wire antenna and found that it had a capture area much larger than its geometrical cross sectional area. These physical data reminded Fleming of an analogous situation in atomic physics:

> It is well known that a photoelectric emission of electrons can occur with an impact of radiation, the surface density of which is so low that the amount captured on the surface of a single atom is far below the known ionizing energy. ... If the only energy which can enter the atom is that drawn from an area of the wave-front equal to the atomic apparent area, it would require an exposure of about a quarter of an hour to such feeble light (a candle flame at 10 feet) before the potassium surface could emit electrons.

Fleming goes on to describe the field interaction between an incident electromagnetic plane wave and an induced dipole field of an atom or an antenna ... the same interaction that explains the otherwise anomalously large effective area of either system. Fifty years later Bohren[8] published his paper on the same phenomenon as it relates to the interaction of photons with small particles, and Paul and Fischer[9] published their paper on the same phenomenon as it relates to the interaction of photons with atoms. The very title of Bohren's paper, "How Can a Particle Absorb More Energy Than is Incident On It?" suggests surprise at the rediscovery of the solution to the problem.

The relatively large area from which energy is drawn into a small antenna is referred to in older antenna engineering texts as the "effective area" or "receiving cross section" of the antenna, but the mechanism responsible for it is not discussed.[10-13] One author[12] states: "But some antennas of physically small cross section may have considerably larger Receiving Cross Sections. It is as though such an antenna has the ability to 'reach out' and capture power from an area larger than its physical size." Another author[13] states simply that "consequently, the larger the directive gain of the antenna, the larger the space from which the antenna derives energy." Modern antenna reference books[14] give the definition of effective area (power received by an antenna divided by incident power density) and nothing more, or are completely silent on the subject, since there is an alternative presentation that does not require the concept of effective area. For example, one author[12] points out that because of the connection between the receiving cross section and the gain, "... the concept of the receiving cross section of an antenna is not a necessary one."

Much work has been done on the study of the limitations of small antennas.[15-19] It has been pointed out that a small, lossless tuned antenna can take from a radio wave and deliver to a conjugate matched load "... an amount of power independent of the size of the antenna. This would be true at one frequency if the antenna can be resonated at that frequency without adding dissipation. It results from the fact that a smaller antenna delivers its lesser voltage from a lesser resistance such that the available power remains the same."[15] In the case of a tuned antenna low loss implies narrow bandwidth. We show that high sensitivity can be obtained without sacrificing bandwidth by employing negative impedances instead of conjugate matched loads. Looked at another way, if the antenna impedance consists of a resistance in series with an inductive reactance, the broadband equivalent of a conjugate load is a resistance in series with a negative reactance. In the ordinary resonant case the reactances cancel at one resonance frequency, and in the broadband case the reactances cancel over all frequencies.

Incidentally, Wheeler also shows that "the power available from such an antenna (one having zero dissipation) is the wave power which would pass through the 'effective area' of the antenna.(15) Its 'effective area' is 3/2 the area of a circle whose radius is one radian length, denoted a 'radian circle.'" (Wheeler defines radian length as $1/2\pi$ wavelength.[20]) At ULF and ELF frequencies, where the wavelength may be hundreds or thousands of kilometers, this implies that small antennas are capable of extraordinary performance. By introducing negative impedances into an antenna circuit to approximate the zero dissipation condition, one would expect to obtain high sensitivity. Note that Wheeler's definition of "effective area" is not the same as the definition of effective area given by Lo and Lee.[14] Wheeler's "effective area" can be taken as the zero dissipation upper limit of effective area.

We begin our design with the analysis of Paul and Fischer.[9] In fact, it was the beautiful and compelling Poynting vector field diagrams in their article, reproduced

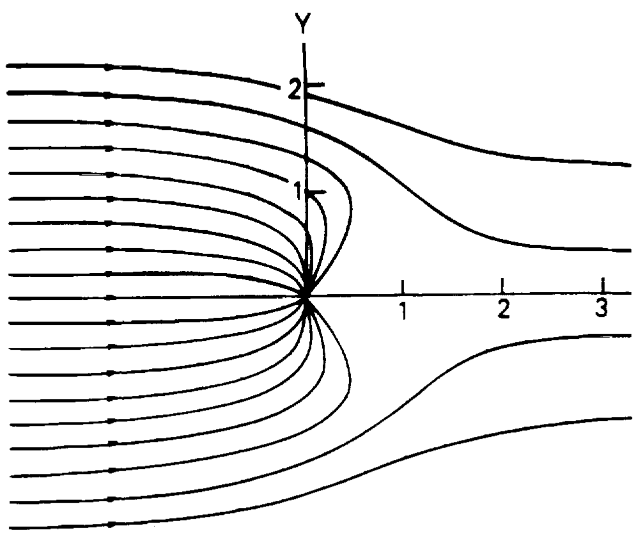


Figure 1. Power flux lines in the x, y plane. The dipole located at $x = y = 0$ oscillates in the z direction. Incident from the left is a linearly polarized monochromatic plane wave (after Ref. 6).

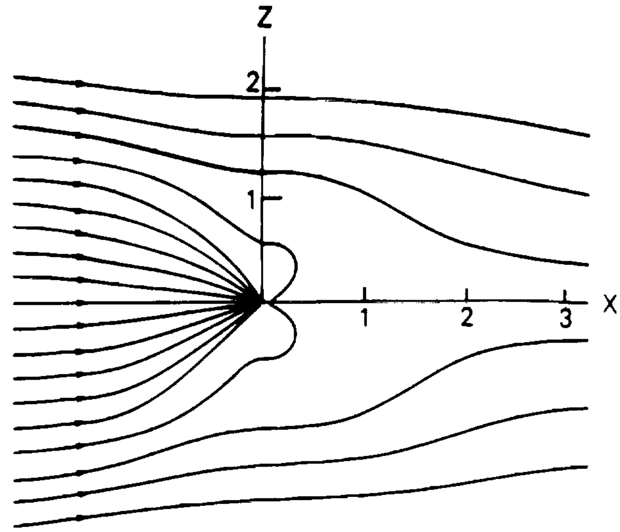


Figure 2. Power flux lines in the x, z plane, for the same physical situation as in Fig. 1 (after Ref. 6).

here as Fig. 1 and 2, that stimulated the authors to try the active antenna approach. (We hasten to add that Bohren[8] also included Poynting vector field diagrams in his article. As so often happens, two researchers, working independently during about the same time period, developed the same concept.) Specifically, the problem treated by Paul and Fischer is that of light absorption by an atom modeled as a dipole. Using a semiclassical approach, they calculate the Poynting vector, **S**, for an incident plane-polarized electromagnetic wave superimposed on the induced dipole field, where the resulting magnetic vector is given by

$$\mathbf{H} = \mathbf{H}_I + \mathbf{H}_D, \tag{1}$$

and the electric field vector is

$$\mathbf{E} = \mathbf{E}_I + \mathbf{E}_D. \tag{2}$$

The subscripts I and D are used to denote "incident" and "dipole," respectively. The result is

$$\begin{aligned}\mathbf{S} = \mathbf{E} \times \mathbf{H} &= (\mathbf{E}_I + \mathbf{E}_D) \times (\mathbf{H}_I + \mathbf{H}_D) \\ &= (\mathbf{E}_I \times \mathbf{H}_I) + (\mathbf{E}_I \times \mathbf{H}_D) + (\mathbf{E}_D \times \mathbf{H}_I) + (\mathbf{E}_D \times \mathbf{H}_D). \end{aligned} \tag{3}$$

The fourth term is assumed to be small and is neglected in the subsequent analysis.

Figures 1 and 2 are reproductions of the results of a numerical study conducted by Paul and Fischer. These figures are qualitatively the same as those that would result from a purely classical treatment of an electromagnetic plane wave incident on a small tuned current loop, because the exterior field of a current loop approximates a dipole field. Instead of an atomic matrix element determining the frequency response, that is, the magnitude of the effect as a function of frequency, the tuning of the inductance of the current loop is provided by a capacitor. Unlike the atomic case, in the steady-state case of a plane wave exciting a current loop, the fourth term may not be negligible. This implies that the Poynting vector field of a radiating dipole will be superimposed on the patterns of Figs. 1 and 2. For further details of the solution, the reader is referred to Paul and Fischer's paper.[9]

Figures 1 and 2, then, in addition to representing the Poynting vector patterns for a photon interacting with an atom, can also be taken to be illustrations of the Poynting vector patterns for a plane wave electromagnetic field interacting with a tuned magnetic dipole receiving antenna. Note that the Poynting vector field lines curve in toward the dipole, indicating power flow from a broad area of the wave front into the dipole. If this effect could be attained with a current loop (or a small cylindrical coil) which is tuned to a broad band of frequencies simultaneously, the result would be a more sensitive receiving antenna with a response that is independent of frequency, as required. An ideal parallel resonant circuit consisting of an inductance L, a capacitance C, and a resistance R, with uniform response and infinite bandwidth, can be realized by selecting $(R/2)^2 = L/C$.[21] This approach has limited usefulness because of the required constraint on interdependence of the values of L, C, and R. A more flexible and useful approach is to connect the positive inductance in series with a negative inductance so that the net inductance is still positive, but very small.

Sensor coils, of course, have complex impedances that

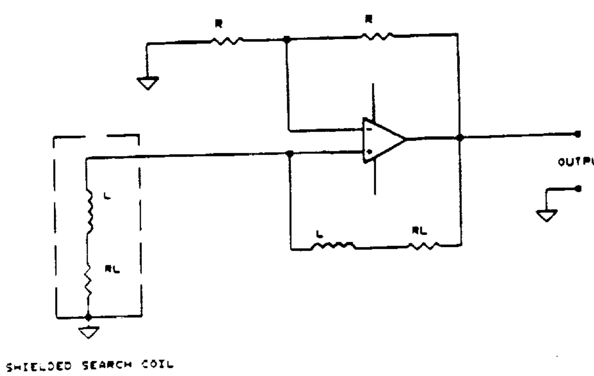


Figure 3. Gain-of-2 impedance converter.

include wire resistance and inductive reactance, and an impedance coupled in from the environment. Accordingly, in order to apply this active antenna principle to a broadband antenna, it is necessary to introduce at least negative resistance and negative inductive reactance into the sensor coil circuit. One way to do this is to connect the coil to a gain-of-2 circuit, as illustrated in Fig. 3. The gain-of-2 circuit has an input impedance which is the negative of any impedance connected between its noninverting input and output. A resistance and an inductance equal to the coil resistance and inductance, respectively, are connected in series across the amplifier. A capacitance can also be added to negate the coil distributed winding capacitance.

Alternatively, a second coil, built to match as closely as possible the physical characteristics of the sensor coil, can be connected across the amplifier. The net impedance of the sensor coil-active amplifier circuit in either case is then much less than the impedance of the sensor coil alone. Note that we are not concerned with matching the antenna impedance to a load resistance. Rather, we want to maximize the effective area of the antenna. Of course, conservation of energy demands power balance. Instead of a power balance consisting of power flowing into the antenna from the incident field balanced by power dissipated in a load resistance and power reradiated, we now have a power balance consisting of power flowing into the antenna (augmented by virtue of the increased effective area) from the incident field plus power flowing into the antenna from an amplifier balanced by the power dissipated in a load resistance and power reradiated.

Another approach is to employ an active circuit such as that of Fig. 4. This is an illustration of the use of an active circuit to synthesize a negative inductive reactance from a capacitance. The input impedance, looking into the noninverting input terminal of the operational amplifier, is

$$Z_{IN} = E_{IN}/I_{IN}. \qquad (4)$$

The input current, accordingly, is

$$I_{IN} = (E_{IN} - E_{OUT})/R_3. \qquad (5)$$

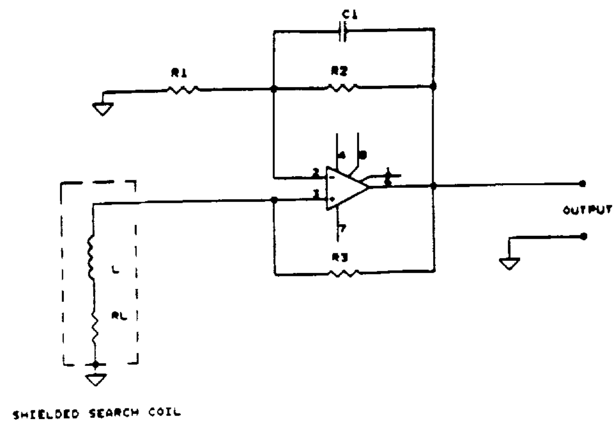


Figure 4. Negative inductance, negative resistance preamplifier.

Now, the output voltage is

$$E_{OUT} = E_{IN} x (1 + Z_2/R_1). \qquad (6)$$

Substituting (2) and (3) into (1) yields

$$Z_{IN} = -R_1R_3/R_2 - j\omega C_1R_1R_3. \qquad (7)$$

Thus the input impedance is a negative resistance with a value

$$R_{EFF} = -R_1R_3/R_2 \qquad (8)$$

and a negative inductance with a value

$$L_{EFF} = -C_1R_1R_3. \qquad (9)$$

The "shorted coil" configuration shown in Fig. 5 is currently in common use for sensors employed in ELF magnetic field measurements. It is also of interest because it forms the basis for an improved active antenna design. In this configuration the coil terminal is connected to the summing junction of an operational amplifier. The summing junction is a virtual ground which therefore maintains a zero potential difference across the coil. Due to the restriction to zero potential difference, the distributed winding capacitance cannot be charged and is therefore effectively removed from the circuit. The emf generated by the coil is proportional to the rate-of-change of magnetic field, resulting in a positive 6 dB-per-octave frequency response slope. The inductive reactance of the coil also has a positive 6 dB-per-octave slope, so by Ohm's law the coil current is independent of excitation frequency. Hence the output voltage also is independent of frequency. The circuit of Fig. 6 is a modification of the basic "shorted coil" configuration. The modification consists of additional circuitry that introduces negative resistance and negative inductive reactance. After an analysis similar to that given above for the circuit of Fig. 4, the input impedance at

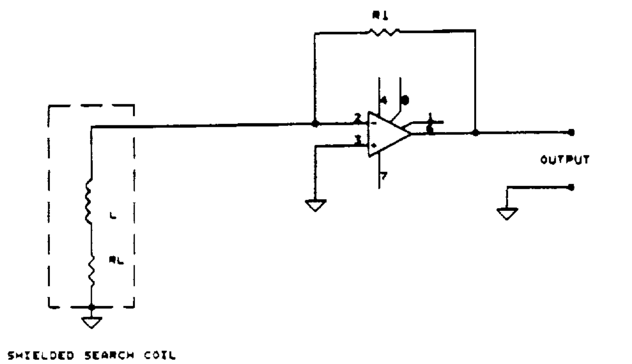


Figure 5. Virtual ground preamplifier.

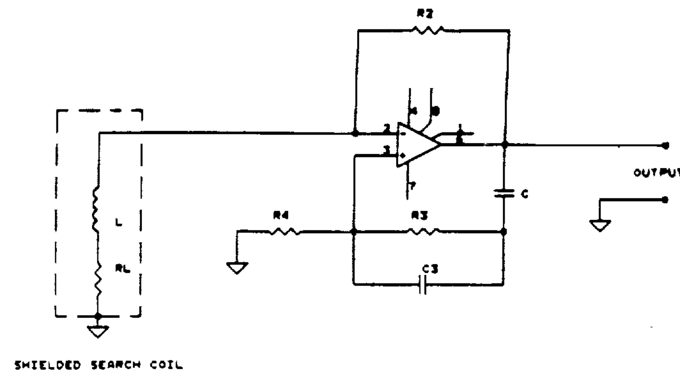


Figure 6. Negative resistance and negative inductance preamplifier.

the inverting input terminal of the operational amplifier of Fig. 6 can be shown to be $Z_{IN} = -sC_3R_2R_4 - R_2R_4/R_3$, which is a negative inductive reactance in series with a negative resistance. With the proper choice of the values of R_2, R_3, R_4, and C_3, one can adjust the total coil-preamplifier circuit impedance to be an arbitrarily small resistance in series with an arbitrarily small positive inductive reactance. That is, the antenna circuit can be adjusted to have an extremely small impedance to current flow, not just at one resonant frequency, but over a broad band of frequencies. For example, assuming a typical coil inductance of 1 H and a coil resistance of 10 Ω, the values of the circuit components could be chosen as follows: $R_2 = R_3 = 100$ kΩ, $R_4 = 10$ Ω, and $C_3 =$ 1 µF. This is the condition for an untuned equivalent to a tuned antenna coil with regeneration and should produce the maximum possible linear interaction with the incident electromagnetic plane wave field over a broad band of frequencies. In addition to performing the function of injecting a negative impedance into the antenna circuit, the operational amplifier also serves as a low noise signal preamplifier.

3. MEASURED RESULTS

As a point of reference, and a matter of curiosity, we wished first to confirm experimentally, in the case of a *tuned* coil, the principle that current in the search coil causes an interaction with the signal field such that energy is intercepted from an effective area greater than the antenna geometrical area. We were aware of the existence of the phenomenon, but wanted to get some firsthand experience with it by making a physical measurement. Actually, the initial experimental measurement suggested itself, because a suitable signal source and test coils were readily available.

Accordingly, a preliminary experimental test was performed on a tuned, regenerative loop antenna-amplifier receiver circuit. The circuit diagram for this receiver is given in Fig. 7. The negative resistance introduced by this circuit was set conservatively so that the antenna exhibited fairly high activity, yet stable performance. For comparison purposes, a simple voltage amplifier, Fig. 8, was also constructed. The voltage amplifier was designed to have a high input impedance to keep coil current to a minimum so that the antenna dipole field-plane wave field interaction would be minimized. These two amplifiers were used in succession to monitor the 24.3 kHz sideband generated by the two million watt U.S. Navy radio transmitting station (NAA) in Cutler, Maine. Cutler is far enough from the receiving site in Washington, D.C., that we can assume that the radiation as received in Washington is, to a good approximation, a perfect plane wave.

The coil used for this test consisted of 21 turns of #26 stranded copper wire wound on a 15.9-cm diameter form and with an inductance of 116 µH, a resistance of 1.0 Ω and a distributed wiring capacitance of 47 pF. This pickup coil was connected to each of the amplifiers in turn, and the output measured with a Hewlett Packard model 3582A FFT spectrum analyzer. The results were: voltage amplifier, −80 dB·V; Q-multiplier, −40.5 dB·V. That is, with the same ambient signal field and the same pickup coil in the same position and orientation, the measured output signal of the Q-multiplier circuit was 39.5 dB greater than that of the simple voltage amplifier. The question to be answered was, Can this ratio of output signal voltage magnitudes be accounted for entirely by the ratio of circuit gains?

Computer SPICE[1] circuit analyses were performed to compute theoretical voltage gains. Care was taken to measure the actual component values to better than 1% accuracy to assure accurate analyses. In addition, the conservative setting of the negative resistance of the active circuit reduced the possibility that significant errors would be introduced by the effects of stray capacitances and inductances. The results were: voltage amplifier, +51.6 dB; Q-multiplier, +77.9 dB. That is, the Q-multiplier had 26.3 dB more voltage gain than the voltage amplifier had. Comparing measurement with theory, the difference of 39.5 dB − 26.3 dB = 13.2 dB represents an output from the Q-multiplier circuit, which is more than 4.5 times greater than it would be on the basis of circuit voltage gain alone. This means that the effective area of the coil in the Q-multiplier configuration was over 20 times greater than the geometrical area of the coil, and, therefore, more than 20 times more power was intercepted from the plane wave front, resulting in the 13.2 dB greater

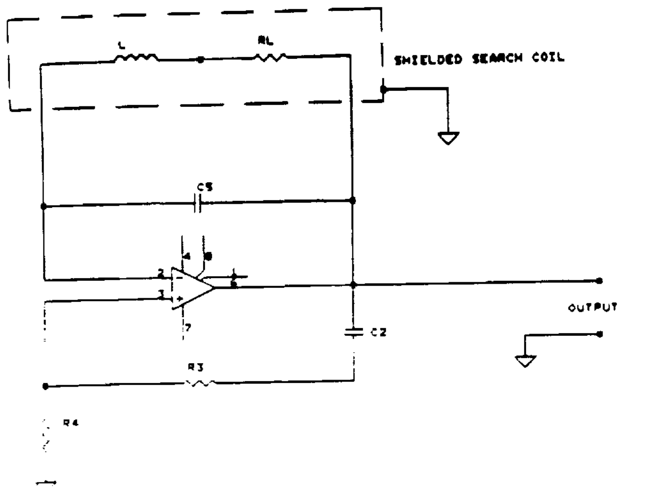


Figure 7. Q-multiplier.

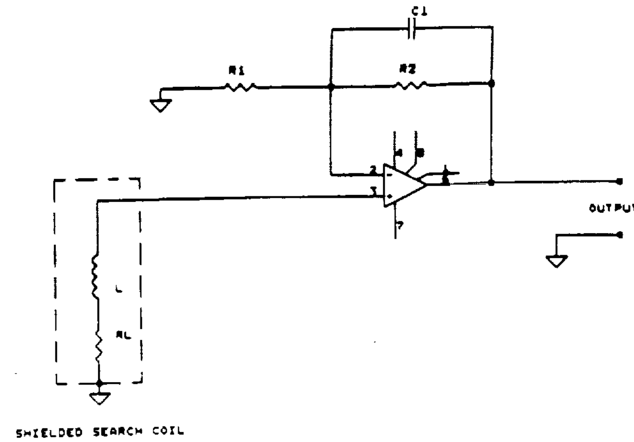


Figure 8. Voltage preamplifier.

output voltage. It is important to realize that this effect is not due to a change in antenna "gain," that is, antenna "directivity" or antenna "pattern." The application of feedback does not change the shape of the original dipole pattern. The sensitivity of the antenna is increased because of the increased effective area caused by the physical interaction of the induced dipole electromagnetic field with the incident plane-wave electromagnetic field.

After this initial verification of the plane wave-dipole interaction in the case of the *tuned* dipole, we wished to confirm experimentally the same interaction in an *untuned* configuration. If a suitable negative complex impedance could be combined in series with the positive complex impedance of the search coil, such that the combined impedance is very small, one would have a sensor coil nearly as sensitive as the resonant one, not just at one particular resonant frequency, but over a broad band of frequencies. That is, the coil would have a large circulating current resulting in an augmented effective area, just as in the case of parallel resonance, but independent of frequency, a "black hole" antenna. This would provide the desired result: a sensitive antenna with uniform response over the entire ULF and ELF frequency bands.

A shielded search coil consisting of a single layer of 1025 turns of #30 enameled copper wire close-wound on a 2.54-cm diameter form, and with a 1.91-cm diameter, 30.5-cm long ferrite core (Amidon Associates part number R-33-075-1200, permeability = 800) was connected to a negative impedance preamplifier circuit. As in the case of the tuned coil, measurements of the broadband antenna output, with the feedback enabled and then disabled, were compared with the theoretical outputs. These measurements were made with a test coil driven with a 48-Hz sinusoidal current. The excitation field in this case was essentially a dipole field, rather than a plane wave field. The active circuit was adjusted such that the antenna afforded near-maximum activity, yet still operated in a stable fashion. As in the tuned case, the ratio of measured output with feedback enabled to that with feedback disabled was compared with the calculated theoretical gain ratio. The difference, 17 dB, represents a sevenfold increase of signal voltage due to the increased effective area of the antenna when feedback was enabled. An increase in output voltage of 17 dB translates to a 34-dB increase, a factor of 50, in power received or in effective area, due to the application of feedback. This is experimental confirmation of the theory that the effective area of the broadband antenna is enhanced due to the introduction of negative resistance and negative inductive reactance into the antenna circuit.

Another test was devised to evaluate the operation of the broadband antenna. It was decided to measure the ambient magnetic field in the vicinity of the sensor coil with the feedback enabled and then disabled. If the magnetic field is distorted by the operation of the active antenna as the Poynting vector field diagrams of Figs. 1 and 2 imply, then it ought to be possible to measure this distortion.

Accordingly, a relatively uniform field was provided by a Braunbek coil configuration, with 12.19-m diameter coils, excited sinusoidally at 20 Hz. A low frequency was chosen in order to avoid phase shifts that might significantly unbalance the coil currents at higher frequencies. A search coil, connected to a cathode ray oscilloscope, was used to sense the relative magnetic field strength. With the feedback disabled, a survey in the vicinity of the antenna coil confirmed that the ambient magnetic field was indeed uniform. With feedback applied, it was found that the magnetic field in the vicinity of the antenna coil was markedly nonuniform, as expected. Figure 9 is a graph of the relative field strength as measured as a function of radial distance from the center of the search coil to the center of the (active antenna) sensor coil. Note that with feedback applied, the field near the sensor coil is significantly reduced. This is a direct indication of the existence of the dipole-plane wave field interaction predicted by theory.

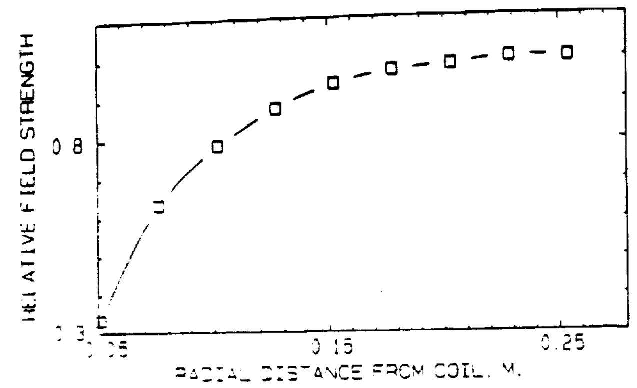


Figure 9. Relative field strength as a function of radial distance from sensor coil.

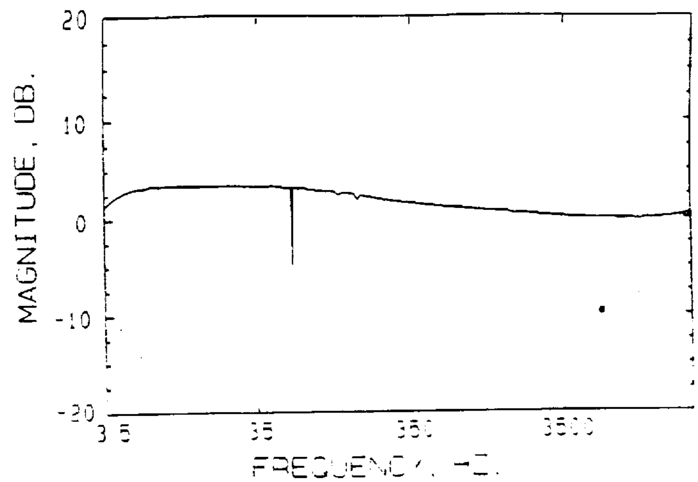


Figure 10. Active antenna frequency response magnitude.

To complete our evaluation of the broadband active antenna, we measured its frequency response. A Hewlett-Packard model 3582A FFT spectrum analyzer was employed to make this measurement. The 3582A's periodic pseudorandom white noise source, which is synchronized with the analyzer analysis period, provided the drive for an active circuit voltage-controlled current source, which, in turn, provided current to a test coil, which was placed in close proximity to the antenna coil. The current source, because of its high output impedance, eliminated the variation of current with frequency which would otherwise occur due to the presence of the inductive reactance of the test coil and due to coupling with the sensor coil. Some difficulty was experienced because of the high ambient magnetic field noise in the laboratory (principally the harmonics of the 60-Hz line frequency), but spectrum averaging over 256 spectra for each data run produced acceptable results. That is, the noise "spikes" at 60 Hz, 120 Hz, and 180 Hz in the data curves are easily distinguishable from the true transfer function. The model 3582A has a linear frequency scale, and it was necessary to make data acquisition runs with the full scale set to 100 Hz, 1000 Hz, 10 000 Hz and 25 000 Hz. The results of these data acquisition runs are combined in Fig. 10. Note the complete lack of resonant response. This means that the broadband antenna behaves over a broad band of frequencies in the same way that the active tuned antenna does at a particular resonance frequency, that is, it has enhanced effective area, not just at one resonance frequency, but, due to the introduction of negative resistance and negative inductance, over a broad band of frequencies. This is experimental justification for our dubbing the broadband active antenna a "black hole" antenna. Over our required frequency range of approximately 8 Hz – 100 Hz, the frequency response is uniform ±0.3 dB. Over a nearly four-decade frequency range, from 3.5 Hz – 25 kHz, the frequency response is uniform, ±2 dB. The variation of ±2 dB is believed to be due to the effects of stray capacitances and limited open loop gain of the operational amplifiers employed. Measurements above 25 kHz were not made, because 25 kHz is the upper frequency limit of the analyzer. The low frequency limit, 3.5 Hz, is adequate for our immediate needs because the lowest Earth-ionosphere cavity resonance frequency is above 3.5 Hz, in the vicinity of 8 Hz. However, expanded low frequency response down to 0.1 Hz may be necessary for future planned applications to earthquake prediction.[2,4]

We have demonstrated a sensor coil antenna in the shorted coil configuration to scientists and engineers. The shorted coil configuration is a configuration in common use currently in ELF work. In the shorted coil configuration, as described earlier, one terminal of the coil is connected to signal common, and the other is connected to a virtual ground, that is, the summing junction of an operational amplifier in the inverting amplifier configuration. By virtue of this bit of circuit sorcery, essentially no potential difference can exist across the coil terminals, the distributed winding capacitance cannot be charged, and so the capacitance is effectively removed from the system, resulting in a nonresonant, broadband response. Typically this demonstration is met with surprise. But once we have demonstrated the zero impedance "black hole" antenna and explained its funcitoning, the reaction is usually either one of astonishment or total disbelief. The first question usually asked is something to the effect, If this is so, why do these Poynting vector field diagrams (such as those of Fig. 1 and 2) not appear in most electromagnetic theory and antenna textbooks? It is true that most textbooks do not include such diagrams, but a reviewer has called our attention to one book[22] that does include them. Because such diagrams are so effective in presenting graphically the key to an otherwise puzzling interaction, undoubtedly they will be included in more textbooks in the future.

4. CONCLUSION

We began our work with the known plane-wave electromagnetic field-resonant dipole electromagnetic field interaction which can explain equally well the enhanced effective areas of photon-atom, photon-particle, and radio wave-tuned dipole interactions. We have extended this principle by showing theoretically and demonstrating experimentally that active circuitry can be used to introduce negative impedances into an antenna circuit to produce this same interaction over a broad band of frequencies. The interaction has been applied to enhance the sensitivity of physically small untuned search coils, used in the study of the ionosphere via the Earth-ionosphere cavity resonances, nominally in the 1 Hz – 100 Hz range. The active antenna frequency response has been measured and confirmed to be free of resonances and uniform, ±2 dB, over a nearly four-decade range of frequencies from 3.5 Hz – 25 kHz.

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Résumé

On décrit ici une antenne magnétique unique ULF-ELF à large bande passante. Des circuits actifs sont utilisés pour introduire une impédance négative qui se combine avec la résistance du conducteur, la capacité distribuée du bobinage et avec l'inductance d'une minuscule bobine de recherche pour produire une antenne ayant une impédance très petite. Le résultat est une augmentation du courant de la bobine de recherche et l'amélioration de l'interaction du champ de l'antenne dipolaire avec le champ d'ondes planes qui augmente considérablement l'aire efficace de l'antenne, indépendamment de sa fréquence – une antenne "trou noir".

Endnote

[1] SPICE is an acronym for "simulation program with integrated circuit emphasis." It is a general-purpose electronic circuit simulation program that was developed at the University of California at Berkeley and released in 1972. Several software companies have developed enhanced versions of the original SPICE, and these software packages have been in wide use in the field of circuit design in the last few years. We have become familiar enough with the properties of one version, PSPICE, developed by Microsim Corporation, to be confident that when used properly, it can predict circuit performance with an accuracy at least as good as that of the measurement equipment we have used for verification of circuit performance.

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